United States
Environmental Protection
Agency

Region 5
77 West Jackson Boulevard
Chicago, Illinois 60604

EPA 905-R-96-005
NTS
September 1998

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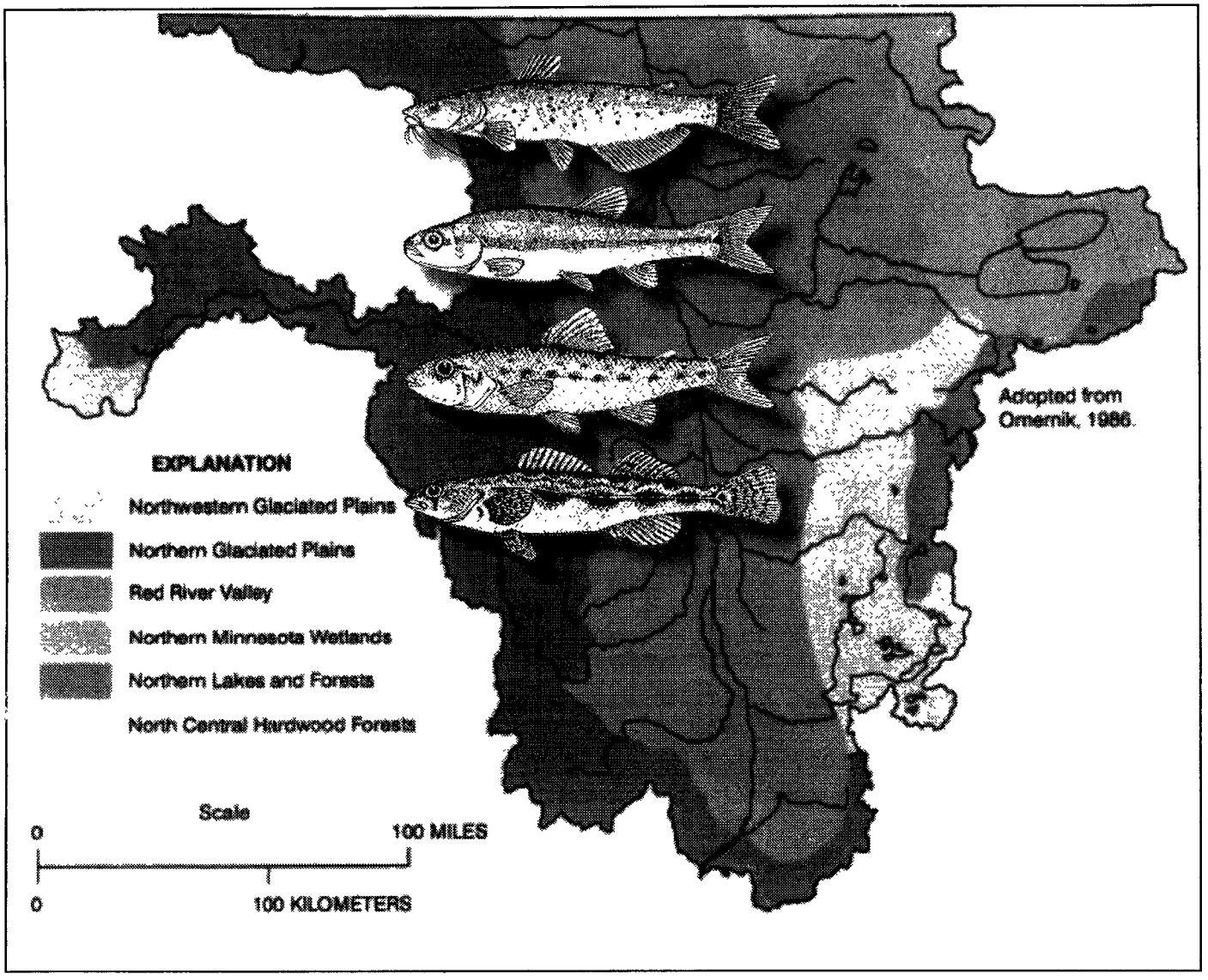
EPA

Development of Index of Biotic Integrity Expectations for The Lake Agassiz Plain Ecoregion



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EXECUTIVE SUMMARY

The index of biotic integrity (IBI) has been used to evaluate the biological quality of rivers and streams in diverse areas of the United States. The IBI compares characteristics of lotic systems, termed "metrics", that represents the structural and functional attributes of the fish community in three categories: 1) species richness and composition, 2) trophic structure, and 3) fish abundance and health. Comparisons are made with lotic systems possessing unaffected or minimally affected communities from ecologically similar areas. Modifications of the metrics have been made to account for regional or local characteristics of fish communities. A combined project between the USGS; USEPA, Regions V and VIII; Minnesota Pollution Control Agency; Minnesota DNR; and the North Dakota Department of Health, Division of Water Quality targeted the multi-state Lake Agassiz Plain (formerly the Red River Valley) ecoregion for IBI development and assessment. All of the metrics have been modified for application to this biologically young (since glaciation) system. Several new metrics are proposed for various stream sizes in the Lake Agassiz Plain ecoregion. New metrics include the evenness component of diversity, trophic composition metrics based on biomass, a new definition for the omnivore feeding strategy, and as an alternative metric, the number of cyprinid species with subterminal mouths. These new metrics are designed to address the uniqueness of the climate, hydrology, and biology of the region.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to those individuals who made significant contributions to this study. The idea to conduct this study was conceived and initiated by Phil Johnson, formerly USEPA Region VIII, Mike Ell, North Dakota Department of Health, and Patricia Bailey, Minnesota Pollution Control Agency. Funding was provided by Susan Jackson, U.S. EPA, Headquarters, Office of Science and Technology. We thank the Minnesota Department of Natural Resources, specifically John Enblom and Konrad Schmidt for their sampling and field expertise. We also thank Mike Feist and Nick Proulx who worked as interns for the MPCA during a hard summer of sampling and showed great perseverance and dedication. Louise Hotka and Sandy Bissonette of the MPCA also should be thanked for their contribution to the effort. Appreciation goes to the North Dakota Game and Fish Department personnel, especially Lynn Schluetter, Andy Thompson, BJ Kratz and Paul Seyer. Pete Wax of the North Dakota Department of Health provided assistance in the field and Allen Johnson and Dan Bain provided their expertise for computer related problems. Special gratitude goes to Dr. John Peterka, Professor, North Dakota State University, for his time spent vouchering specimens. The species list was provided by Todd Koel, Ph.D. candidate, North Dakota State University. Thanks to Willis Mattison and local SWCD staff for information about river conditions. Dr. James Underhill and Dr. Jay Hatch of the Bell Museum assisted in taxonomic identification and vouchering fish specimens collected in Minnesota. Maps were provided by Carrie Bartz of the MPCA and personnel from USGS.

Development of Index of Biotic Integrity Expectations

for the Lake Agassiz Plain Ecoregion of Minnesota and North Dakota

1.0 INTRODUCTION

Biological integrity is defined as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region (Karr and Dudley 1981). One of the most widely accepted analytical tools used to measure biological integrity is the Index of Biotic Integrity (IBI). The IBI was developed in 1981 to evaluate fish community structure and function in midwestern wadable streams and rivers (Karr 1981; Karr et al. 1986). This index relies on multiple variables (termed "metrics") based on community concepts, to evaluate a complex biotic system. It incorporates professional judgement in a systematic and sound manner, but sets quantitative criteria that allows determination of a continuum between very poor and excellent based on species richness and composition, trophic and reproductive constituents, and fish abundance and condition. Since the metrics are differentially sensitive to various perturbations (e.g. siltation or toxic chemicals), as well as various degrees or levels of change within the range of integrity, conditions at a site can be determined with considerable accuracy.

The IBI has been viewed as a family of multi-metric indices that needs to be modified for regional use (Miller et al. 1988; Simon and Lyons 1995). Various permutations of the original IBI have been developed for use for use in warmwater streams in northern sections of the Midwest (Simon and Lyons 1995), Wisconsin (Lyons 1992), southern Minnesota (Bailey et al. 1993), and southern Ontario (Steedman 1988). However, the species depauparate systems of the Hudson Bay drainage have not been evaluated.

Because water within the Red River of the North Basin (referred to in the text as the Red River Basin) flows northward through prime agricultural lands in the United States into Canada (Fig. 1), water quality throughout the basin is an international concern; particularly in the agriculturally impacted region of the Lake Agassiz Plain. Goldstein et al. (1994) emphasized multi-agency cooperation to develop an IBI that could provide resource managers in the Red River of the North Basin with a common tool to evaluate water resource quality, irrespective of political boundaries. The States of Minnesota and North Dakota have recognized the importance of developing numerical biological criteria to establish benchmarks to assess water quality degradation in this heavily impacted basin. In addition, statewide numerical biological criteria have been an important component of the U.S. Environmental Protection Agency's biocriteria program and monitoring and assessment objectives (USEPA 1996). The U.S. Geological Survey has recently completed an assessment of water quality in the Red River Basin as part of the National Water Quality Assessment (NAWQA) program (Stoner 1991). Further mention of the Red River Basin will refer only to that portion within the United States.

Objectives:

The purpose of this report to outline the rationale for potential IBI metrics to evaluate the Lake Agassiz Plain ecoregion (formerly the Red River Valley ecoregion) within the Red River Basin. This report includes specific Index of Biotic Integrity criteria including the development of metrics and maximum scoring lines, to delineate areas of high quality within the Lake Agassiz Plain ecoregion of the Red River Basin. We suggest that the criteria presented in this document are a "first attempt" to evaluate rivers and streams in the Lake Agassiz Plain ecoregion.

2.0 STUDY AREA

Drainage Features

Red River of the North Basin

The Red River Basin drains 17,500 mi^2 in northwest Minnesota, 21,000 mi^2 in eastern North Dakota, and 800 mi^2 in northeastern South Dakota (Renard et al. 1986). The Red River is the major drainage unit in the basin (Fig. 1). The river meanders northward for 394 miles to the United States-Canadian border (IRRPB 1995). The mean annual flow of the Red River increases from 519 cfs at its source at the confluence of the Bois de Sioux and Otter Tail Rivers (Renard et al. 1986) to 3386 cfs at the United States-Canadian border (IRRPB 1995). Much of the flow occurs during the spring and early summer months when snow melt and heavy rains can cause

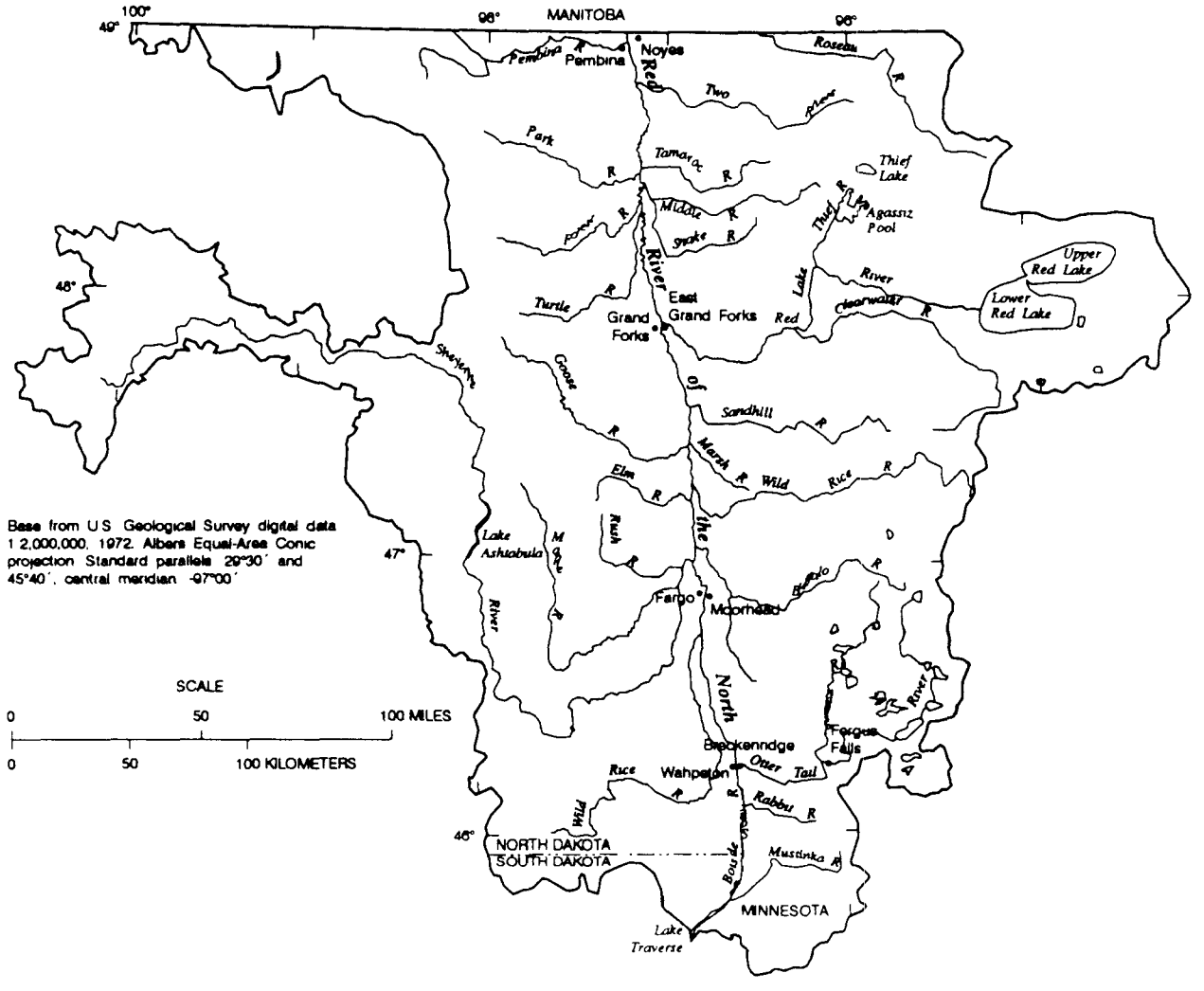

Figure 1. Major rivers in the Red River of the North Basin.

severe flooding. The gradient gradually declines from 1.3 ft/mi at Wahpeton-Breckenridge to 0.2 ft/mi at the United States-Canadian border (Stoner et al. 1993).

About 75% of the Red River's flow orginates from tributaries in Minnesota (Tornes and Brigham 1994). The largest of these tributaries, the Red Lake River, enters into the Red River at East Grand Forks. With an mean annual flow of 1110 cfs, the Red Lake River contributes almost 1/3 of Red River's flow (Renard et al. 1983). Other major tributaries of the Red River in Minnesota from south to north include the Mustinka, Otter Tail, Buffalo, Wild Rice, Marsh, Sandhill, Snake, Middle, Tamarac, Two, and Roseau Rivers.

Tributaries to the Red River in North Dakota contribute substantially less flow. The largest tributary to the Red River in North Dakota is the Sheyenne River with a mean annual flow of 184 cfs. Other major tributaries of the Red River in North Dakota from south to north include the Wild Rice, Maple, Rush, Elm, Goose, Turtle, Forest, Park, and Pembina Rivers.

Lake Agassiz Plain Ecoregion

The study area was once entirely inundated by an immense glacial lake known as Lake Agassiz. Lake Agassiz once covered over 22,000 mi^2 in Minnesota, South Dakota and North Dakota (Waters 1977). During the 12,000 years since the last glacial retreat the waters of the basin have warmed, erosion has cut new and deeper stream channels, drainage patterns have changed, and vegetation has changed. Many of these changes came about or were accelerated by human activities. The rich glacial lake sediments left behind by Lake Agassiz were highly desirable for agriculture. The native vegetation, mainly tall grass prairie, was cleared for the production of wheat, other small grains, corn, potatoes, soybeans, and vegetables. The land was drained and treated with fertilizers, herbicides, and pesticides to increase productivity. Currently, over 90% of the land in counties bordering the Red River in Minnesota have been cultivated (MPCA 1994).

Since the soils of the Red River Basin were naturally poorly drained, a massive system of drainage ditches was built to bring the land into production. In Minnesota alone, over 7,400 mi of drainage ditches were created in the Red River Valley since the late 1800's (USGS 1974). To further move water rapidly off the land, many streams were channelized and a system of flood control impoundments were built to control flooding. These extensive channel modifications along with agricultural run off and wastewater inputs from industrial and municipal sources altered the physical, chemical, and biological makeup of rivers and streams in the Red River basin.

Ecoregions (Omernik 1987) were used to determine the geographic boundaries of different areas within the basin. Omernik (1987) mapped the ecoregions of the conterminous United States from maps of land-surface form, soil types, potential natural vegetation, and land use. Ecoregions were defined as areas of homogeneous ecological systems or areas that have the potential (if undisturbed) for similar biological communities (Omernik and Gallant 1988). The Lake Agassiz Plain ecoregion was the only ecoregion that was entirely included in the Red River Basin. However, four additional ecoregions surrounded the Lake Agassiz Plain ecoregion and comprised the outer portion of the basin (Fig. 2). The other four ecoregions in the basin were the North Central Hardwood Forests, Northern Minnesota Wetlands, Northern Glaciated Plains, and Northern Lakes and Forests.

Because of Lake Agassiz's influence on the basin, the land in the central portion of the basin was significantly different than the land at the outer edges and as a result, so was the condition of the water resources. Headwater reaches of most major tributaries to the Red River originated in the outer ecoregions (Fig. 1 and 2). The majority of these tributary streams were higher in gradient, had definitive geomorphological units (i.e., riffles, pools, and runs), and were dominated by course gravel or cobble substrates. As tributary streams entered the Lake Agassiz Plain ecoregion, their gradient decreased and there was a shift in stream morphology to slow moving, meandering runs.

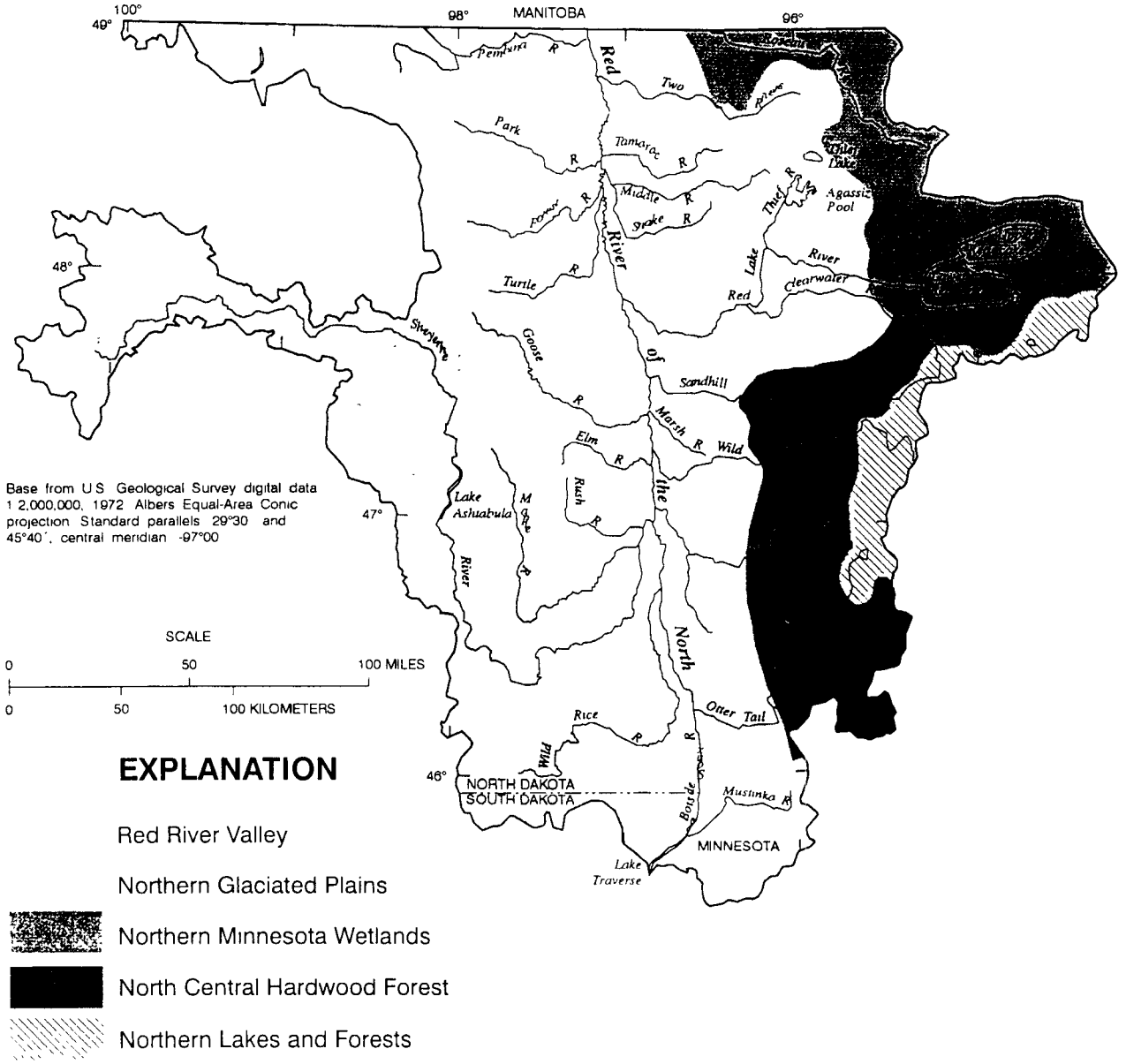

Figure 2. Ecoregions of the Red River of the North Basin (modified from Omernik, 1987).

The fine alluvial deposits of Lake Agassiz were reflected in the substrate of the rivers and streams such that sand, silt, and clay dominate. These physical changes associated with Lake Agassiz affected water chemistry by contributing to an increase in turbidity, conductivity, and total suspended solids.

Historical Red River Valley Data

Physical and chemical characteristics of water resources within the Red River Valley have been summarized in reports on ground and surface water hydrology (Stoner et al. 1993; Maclay et al. 1965; Maclay et al. 1967; Maclay et al. 1969(a); Maclay et al. 1969(b); Maclay et al. 1972; Winter et al. 1967; Winter et al. 1970; Winter et al. 1984), hydrogeology (Ruhl 1986; Siegel 1981), nutrient and sediment transport (Tornes 1986; Tornes and Brigham 1994), and surface water quality (MPCA 1969; MPCA 1977; MPCA 1994). Biological communities of the Red River basin have been summarized in numerous reports including surveys of fish (Enblom 1982; Renard et al. 1983; Renard et al. 1986; Hanson et al. 1984; Neel 1985; Peterka 1978; Peterka 1991), macroinvertebrates (Neel 1985; Hanson et al. 1984), mollusks (Dawley 1947; Cvancara 1970; Cvancara 1983) and aquatic plants (Renard et al. 1983).

Renard et al. (1986) conducted fish community assessments at 14 locations on the Red River. Thirty six species were collected from 12 families. Carp comprised over 50% of the total catch by weight, while game fish were not common in the collection. The most common game fish species were channel catfish (8.2%) and walleye (3.2%). Renard et al. (1983) surveyed the fish community at 8 sites on the Red Lake River in Minnesota, the largest tributary of the Red River. Thirty eight fish species from 13 families were collected during the survey. Of the 6 rivers in North Dakota that Peterka (1991) surveyed, Park River had the greatest number (18) of fish species. Goldstein (1995) summarized historical fish community data from the Red River basin and reported that western tributaries of the Red River supported fewer species than those in the east. Of the 75 species found in the major rivers of the basin, 51 were present in the western half; whereas, 71 were found in the east. Species richness was reported to be affected by drainage area (DA) and the number of ecoregions a river flows through (Goldstein 1995).

3.0 MATERIALS AND METHODS

Establishing the Reference Condition

Reference conditions define the physical, chemical, and biological expectations of minimally impacted rivers and streams (Hughes et al. 1982; Whittier et al. 1987). Properly defined reference conditions provide a reasonable benchmark to measure the degree of water quality degradation (Hughes and Omernik 1981; Hughes et al. 1986).

To determine the reference condition for the Lake Agassiz Plain ecoregion, 111 locations were sampled throughout the ecoregion during June through August 1993-1994 (Fig. 3). These sites were chosen because they were thought to represent least impacted areas of the basin and were considered to be candidate reference sites. In addition, select data from past MDNR fisheries surveys conducted at 102 sites was also added to the database. Only those MDNR surveys that contained information on the entire fish communty and that used electrofishing methods to capture fish were included in the analysis.

Criteria for Selecting Reference Sites

Sites that approximated the regional reference condition were considered candidate reference sites. These sites possessed a well balanced, adaptive aquatic community and chemical and physical characteristics indicative of presettlement times. We used the following criteria to help distinguish a candidate reference site from other sites: 1) The site had a natural stream geomorphology. The stream channel had not been altered by dredging or channelization; 2) There was a continuous riparian area along the reach extending laterally about three times the channel width. Land use was consistent

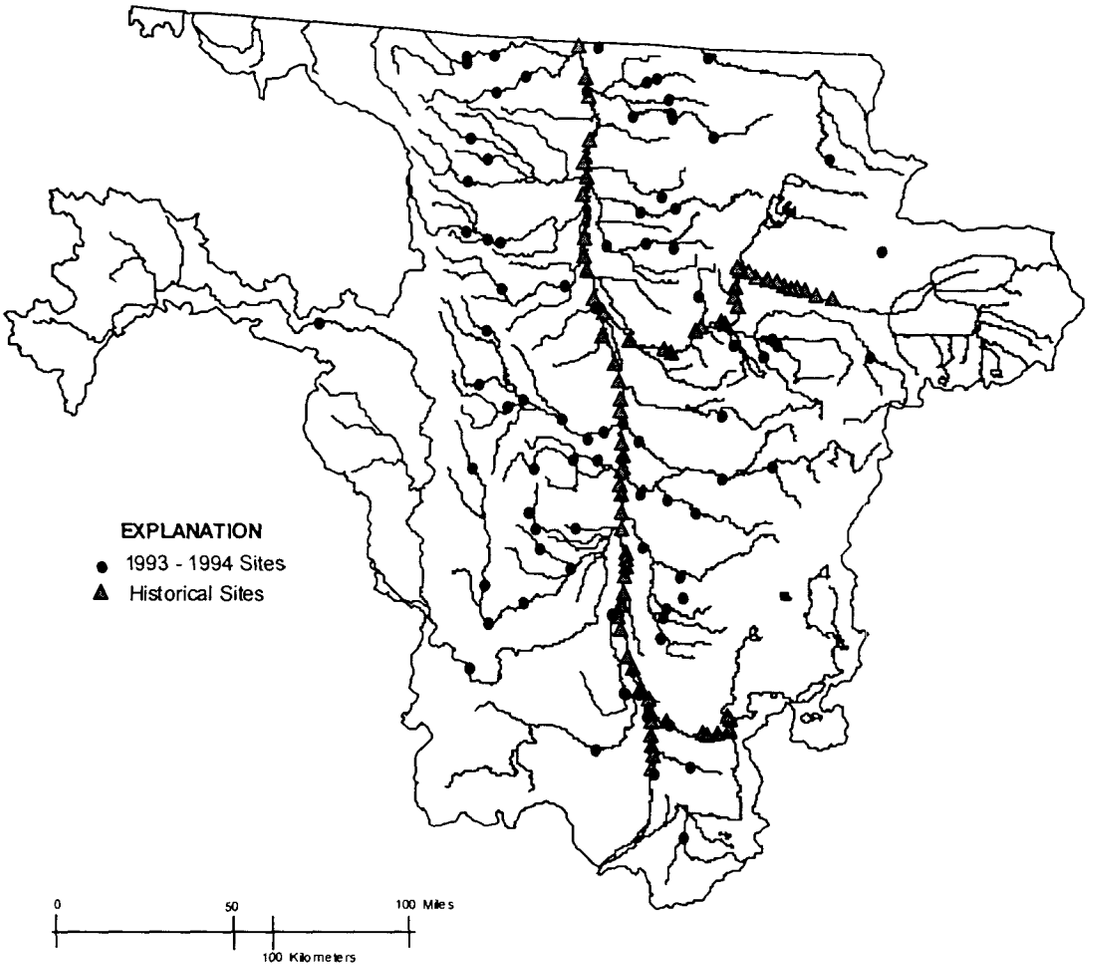

Figure 3. Map of the Red River Basin indicating historical sample locations as well as sample locations during the 1993-1994 study period.

laterally and soils and vegetation are undisturbed; 3) The vegetation was undisturbed within the riparian area. Woody vegetation was not logged or removed. Grasses were not cut, burned, or treated with herbicides. If vegetation was altered historically, the plant community within the riparian area should have had sufficient time to grow back to its predisturbed condition; 4) The stream segment had not been stocked with forage or game fish species; 5) There was no point sources or in-flowing springs, ditches, or drainage canals; 6)The reach geomorphology was consistent with segment geomorphology; 7) There was no stream habitat improvements (wing dams, rip rap, etc.); 8) The site was not snagged. All woody debris remained in the stream unless moved by natural processes; 9) There were no dams or diversions upstream or downstream within two meander cycles or two replications of major geomorphological units; 10) There were no bridges upstream within two meander cycles or two replications of major geomorphological units.

Few sites in the Lake Agassiz Plain met all of these criteria because natural, undisturbed land cover in the ecoregion was almost nonexistent. Therefore, the candidate reference sites could not be considered pristine or undisturbed. Rather, these sites represented the best available conditions given the anthropogenic impacts, channelization, and cultural eutrophication that had occurred in the Lake Agassiz Plain ecoregion.

The selection of candidate reference site locations was based on information from local resource managers, historic fish collections by the Minnesota Department of Natural Resources and the North Dakota Department of Health, and on-site reconnaissance. Obtaining an adequate spatial coverage of the ecoregion also helped determine the site locations.

Whenever available, candidate reference sites included natural areas, parks (federal, state, county, and local), exceptional designated streams, and historical sampling locations. Since ditching occurred at most of the headwater sites in the ecoregion, we selected sites that indicated recovery from channelization or potential non-point source pollution areas and had a stable riparian buffer on the shoreline. When a series of point source dischargers were located on a river, effort was made to sample upstream of the discharger or to search for areas of recovery between dischargers.

When impoundments or other physical habitat alterations had been imposed on a river, the best suitable, stable site was used as a sampling location. "Suitable" in these instances were sites considered free from the adverse affects of impoundments or habitat alterations and those sites which posed no threat of injury to personnel. In areas where sampling could not be accomplished due to lack of access downstream of the physical structure, candidate reference sites were located upstream of the dam away from the immediate influence of the pooled portion. Likewise, bridges were usually sampled on the upstream side, away from the immediate vicinity of the structure and latent bridge construction effects. If downstream sampling was conducted because of habitat considerations, sampling began at least 50 m downstream of the bridge.

Fish Community Sampling Procedures

All sites were rigorously sampled in order to get representative, quantitative estimates of species richness and biomass. Sampling was conducted in all river size classes in the Lake Agassiz Plain ecoregion from headwater streams which we defined as those streams < 200 mi^2 DA, to the large rivers with DA $> 2{,}000$ mi^2. The reach length of each site was determined by multiplying the mean stream width by 15 with a maximum reach length of 500 m. Therefore, stream reach length varied with stream size. Sites ranged in length from 50 m at some headwater sites to 500 m at large river sites.

Sampling took place during the summer to take advantage of the low and stable flow conditions usually found during this time of the year. Karr et al. (1986) found that low to moderate stream flows were preferred and the relatively variable flow conditions of early spring and late autumn should be avoided. Unfortunately, 1993 and 1994 were somewhat atypical because water levels remained high in the Lake Agassiz Plain throughout the

summer months.

Gear selection was dependent on stream size, velocity, substrate, and depth. However, only one electrofishing gear type was used at each site to collect a representative sample (Jung and Libosvarsky 1965; Ohio EPA 1989). A generator powered backpack electrofishing unit or a T&J pulsed-DC generator (300 V, 1750 watts) mounted in a Coleman Sport-canoe, floated in a Sport-Yak, or attached to a long-line was used to sample fish at headwater and moderately sized wadable streams (200-1500 mi^2 DA). Large river sites (> 1500 mi^2 DA) were sampled using a long line, sport-yak, or boat electrofisher (see Ohio EPA 1989 or USEPA 1988 for discussion of gear). Sampling occurred along both shorelines in streams > 5 m width or followed a serpentine pattern on both shores for streams <5 m width.

At each site, we attempted to collect all fish that were encountered. Adult and juvenile specimens from each site were counted and identified to species using the taxonomic keys of Becker (1983), Gerking (1955), and Trautman (1981). Cyprinid taxonomy followed Mayden (1989). Smaller and more difficult to identify taxa were preserved for laboratory examination and identification. Young-of-the-year fish (less than 20 mm in length) were not included in the analysis. Early-life stages may exhibit high initial mortality (Simon 1989) and are often difficult to collect with gear designed for larger fish (Angermeier and Karr 1986). Specimens > 20 mm total length (TL) were easily collected using our gear.

All fish were examined for the presence of gross external anomalies. Incidence of these anomalies was defined as the presence of externally visible morphological anomalies (i.e. deformities, fin or gill erosion, lesions/ulcers and tumors). Specific anomalies included: fin rot; pugheadedness; Aeromonas (causes ulcers, lesions, and skin growth, and formation of pus-producing surface lesions accompanied by scale erosion); dropsy (puffy body); swollen eyes; fungus; ich; curved spine; swollen-bleeding mandible or opercle. Incidence was expressed as percent of anomalous fish among all fish collected. Incidence of occurrence was computed for each species at each station. Hybrid species encountered in the field (e.g. hybrid centrarchids, cyprinids) were recorded on the data sheet, and when possible, potential parental combinations recorded.

Habitat

A general site evaluation for each sampling location was conducted using the Qualitative Habitat Evaluation Index (QHEI), (Ohio EPA 1989; Rankin 1989), and Rapid Bioassessment Protocol (RBP)(Plafkin et al.1989). The QHEI and RBP measured important features of the habitat not only in the channel but also in the surrounding environment. Scoring included information on substrate composition, instream cover, channel morphology, riparian zone and bank erosion, and pool and riffle quality. Physical-chemical parameters were recorded for each site including; dissolved oxygen, pH, temperature, and specific conductivity, as well as general water chemistry (e.g. hardness alkalinity, nitrogen, phosphorus) for North Dakota sites. Equipment used for water quality analysis varied by each agency conducting the surveys, but each meter was used following the specifications of the manufacturer.

Metrics

The interpretation of the original IBI scoring system (Karr et al. 1986) and the scoring system developed for the Lake Agassiz Plain ecoregion is provided in six narrative categories (Table 1). Numerical category boundaries for the Lake Agassiz Plain were determined by comparison of the IBI scores and fish community attributes with the narrative category descriptions provided by Karr (1981).

Below is an explanation of each metric used in the calibration of the Index of Biotic Integrity for the Lake Agassiz Plain. Metric selections were based on the recommendations of Goldstein et al. (1994). Each metric was calibrated using data collected during the 1993-1994 study period and appropriate historical data. The proportion of DELT anomalies and catch-per-unit-effort were based on very little historical information since this information was seldom available in the historical records. Only data

collected during the 1993-1994 study period was presented in the Results and Discussion.

Several of the metrics were drainage size dependent and required calibration to determine numerical scores (Tables 2-4). Drainage size effects were determined by evaluating trends in species or proportions of individuals with increasing (log transformed) DA. Maximum scoring lines were drawn following the procedure of Fausch et al. (1984) and Ohio EPA (1987). Scatter plots of individual metrics were first evaluated for basin specific patterns. The trisection method was used to show the maximum scoring lines. This required that the uppermost line be drawn so that 95% of the data points were beneath the line. The other two lines were drawn so the remainder of the area beneath the 95th percentile line was divided into three equivalent areas. If no relationship with increasing DA was observed, the maximum scoring lines either leveled off at the point where no additional increases were exhibited or horizontal plots were delineated indicating no increase with DA. Deviations from the Fausch et al. (1984) procedure were necessary when outliers were present or when it was determined that the metric did not respond in a linear fashion. This was the the case with the piscivore metric where a high and low proportion of piscivorous species indicated an unbalanced fish community. Differentiation between headwater, moderate, and large river sites was determined by searching for bimodal patterns in the basin specific data set plots. The tails of distribution of the data were not significant. However, the point where the data differentiated into two distinct peaks suggested that the transition between headwater and moderate sized streams was at 200 mi^2 DA and between moderate sized streams and large rivers was at 1,500 mi^2 DA.

Table 1. Total Index of Biotic Integrity (IBI) scores, modified scores for the Lake Agassiz Plain ecoregion, integrity classes, and attributes of IBI classification from Karr et al. (1986).

Karr IBI score	Lake Agassiz Plain	Integrity class	Attributes
58-60	51-60	Excellent	Comparable to the best situation without human disturbance; all regionally expected species for the habitat and stream size, including the most intolerant forms, were present with a full array of age (size) classes; balance trophic structure.
48-52	41-50	Good	Species richness was somewhat below expectations, especially due to the loss of the most intolerant forms; some species were present with less than optimal abundances or size distributions; trophic structure shows some signs of stress.
40-44	31-40	Fair	Signs of additional deterioration included loss of intolerant forms, fewer species, highly skewed trophic structure (e.g. increasing frequency of omnivores and other tolerant species); older age classes of top predators were rare.
28-34	21-30	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish were often present.
12-22	12-20	Very Poor	Few fish were present, mostly introduced or tolerant forms; hybrids were common; disease, parasites, fin damage, and other anomalies regular.
0			No fish

Table 2. IBI metrics used to evaluate headwater streams* (<200 mi² DA) sites in the Lake Agassiz Plain ecoregion.

		Scoring Classification		
Category	Metric	5	3	1
Species richness and composition	Total number of species	Varied with DA		
	Evenness	>0.8	>0.6 and ≤0.8	≤0.6
	Number of minnow species	Varied with DA		
	% Pioneer individuals[1]	Varied with DA		
	% Headwater individuals	>50	>25 and ≤50	≤25
Trophic composition	% Omnivore biomass[1]	<33	≥33 and <66	≥66
	% Insectivore biomass[1]	>60	>30 and ≤60	≤30
Reproductive guild	% Simple lithophilic[1]	>60	>30 and ≤60	≤30
Functional guild	% Tolerant individuals	<31	≥31 and <62	≥62
	Number of sensitive species	Varied with DA		
Fish abundance and condition	Number of individuals per meter	Varied with DA		
	% DELT	<1	≥1 and <4	≥4

*Headwater metrics discussed individually in text.
[1] Special scoring procedures were required when < 25 individuals are collected at the site or the number of species metric is scored a "1" .

Table 3. IBI metrics used to evaluate moderate size streams* (200-1500 mi^2 DA) sites in the Lake Agassiz Plain ecoregion.

Category	Metric	Scoring Classification 5	3	1
Species richness and composition	Total number of species	Varied with DA		
	Evenness	>0.8	>0.6 and ≤0.8	≤0.6
	Number of minnow species	>7	>4 and ≤7	≤4
	Number of benthic insectivore species	>7	>4 and ≤7	≤4
Trophic composition	% Piscivore biomass[1]	>20 and <30	>10 and ≤20, ≥30 and <40	≤10 and ≥40
	% Omnivore biomass[1]	<33	≥ 33 and <66	≥66
	% Insectivore biomass[1]	>60	>30 and ≤60	≤30
Reproductive guild	% Simple lithophilic spawners[1]	>60	>30 and ≤60	≤30
Functional guild	% Tolerant individuals	<31	≥31 and <62	≥62
	Number of sensitive species	Varied with DA		
Fish abundance and condition	Number of individuals per meter	Varied with DA		
	% DELT	<1	≥1 and <4	≥4
Alternative metrics	% Headwater individuals	>50	>25 and ≤50	≤25
	% Pioneer individuals	Varied with DA		
	% Subterm. mouth minnows	>20	>10 and ≤20	≤10
	Number of sucker species	>4	>2 and ≤4	≤2

*Moderate sized stream metrics are discussed individually in text.
[1] Special scoring procedures were required when < 50 individuals are collected at the site or the number of species metric is scored a "1".

Table 4. IBI metrics used to evaluate large river* (>1500 mi² DA) sites in the Lake Agassiz Plain ecoregion.

Category	Metric	Scoring Classification 5	3	1
Species richness and composition	Total number of species	>16	>8 and ≤16	≤8
	Evenness	>0.8	>0.6 and ≤0.8	≤0.6
	% Large river individuals	Varied with DA		
	% Round bodied suckers	>40	>20 and ≤40	≤20
Trophic composition	% Piscivore biomass[1]	>20 and <30	>10 and ≤20, ≥30 and <40	≤10 and ≥40
	% Omnivore biomass[1]	<33	≥33 and <66	≥66
	% Insectivore biomass[1]	>60	>30 and ≤60	≤30
Reproductive guild	% Simple lithophilic spawners[1]	>60	>30 and ≤60	≤30
Functional guild	% Tolerant individuals	Varied with DA		
	Number of sensitive species	>6	>3 and ≤6	≤3
Fish abundance and condition	Number of individuals per meter	Varied with DA		
	% DELT	<1	≥1 and <4	≥4
Alternative metrics	% Pioneer individuals	Varied with DA		
	Number of sucker species	>4	>2 and ≤4	≤2

*Large river metrics are discussed individually in the text.
[1] Special scoring procedures were required when < 50 individuals are collected at the site or the number of species metric is scored a "1".

Metric 1. Total Number of Fish Species (All Streams and Rivers)

Impetus

This metric was used for all stream sizes The metric was considered to be one of the best for determining stream condition due to a correlation between high quality resources and the number of fish species in warmwater assemblages (Ohio EPA 1987; Davis and Lubin 1989; Plafkin et al. 1989; Simon 1991). The rationale for this metric was based on the observation that the number of fish species increased directly with environmental complexity and quality (Karr 1981; Karr et al. 1986).

Non-native species were included for the Lake Agassiz Plain ecoregion. Although the number of non-native or introduced species may be indicative of a loss of integrity (Karr et al. 1986; Ohio EPA 1989), they were included to help discern differences between sites that were at the lower levels of biotic integrity. The only commonly occurring non-native species found in the basin was the common carp Cyprinus carpio and it was introduced over one hundred years ago.

The difference between what was defined as headwater and moderate sized streams in the Lake Agassiz Plain ecoregion was made using information from this metric. We separated headwater and moderate sized streams at 200 mi^2 DA. The number of species was strongly correlated with DA at headwater and moderate sized stream sites up to 1500 mi^2 DA (Fig. 4). There was not a DA relationship for large river sites (> 1500 mi^2 DA) because the number of species reached an asymptote.

This metric was used in deciding the scoring modifications (See Scoring Modifications, last section). When the number of species at a site was extremely low (score equals 1) special scoring was needed because the scores for the proportional metrics did not reflect the true quality of the resource.

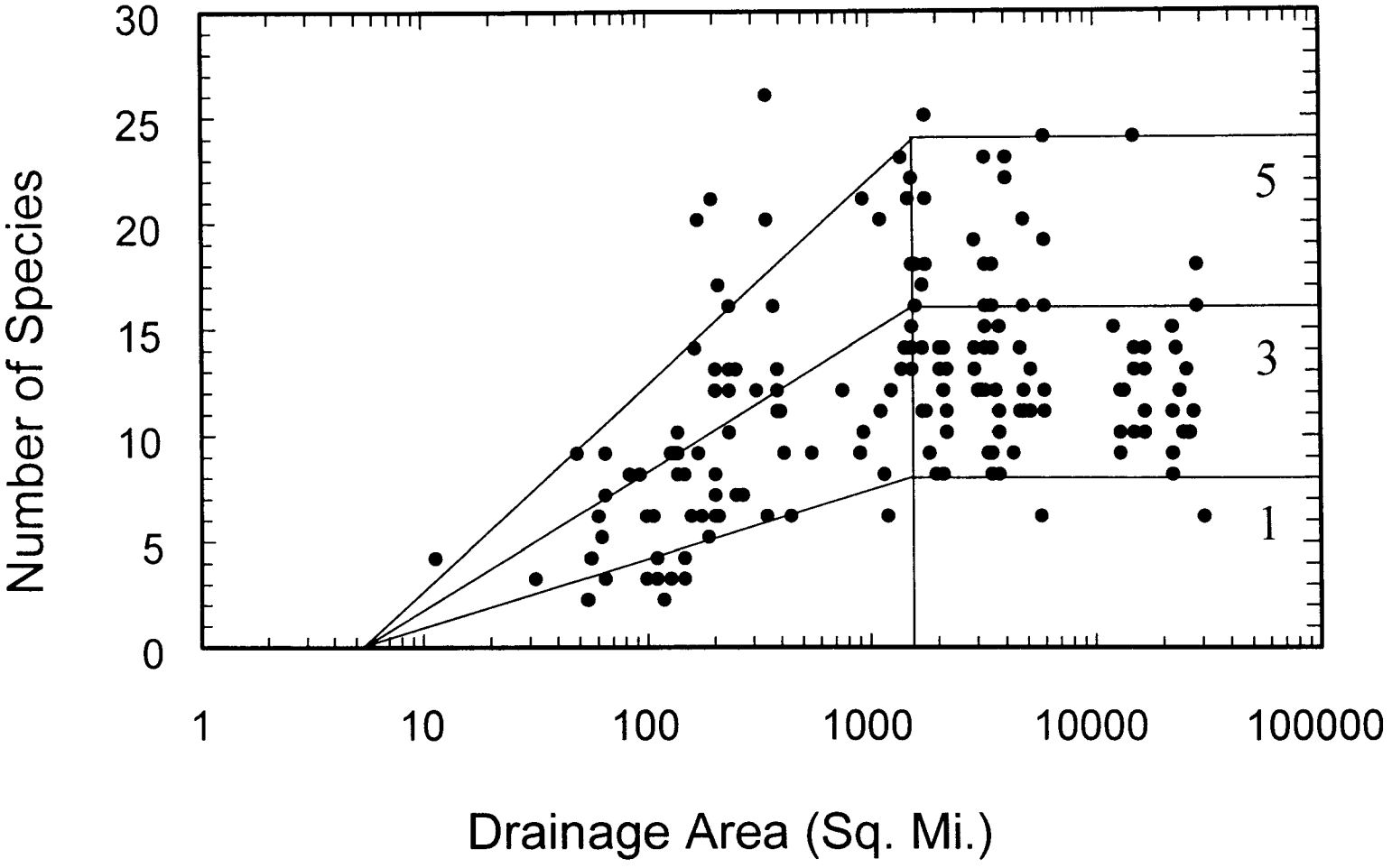

Figure 4: Maximum scoring lines for determining trends in the total number of species with increasing drainage area for the Lake Agassiz Plain ecoregion.

Metric 2. Proportion of Headwater Species (Headwater Streams)
Number of Benthic Insectivores (Moderate Sized Streams)
Proportion of Round-bodied Suckers (Large Rivers)

Impetus

The number of darter species was included in Karr's (1981) IBI. Darters are insectivorous, habitat specialists, and sensitive to physical and chemical environmental disturbances (Page 1983; Kuehne and Barbour 1983). Darters are indicators of a quality resource, and are generally found in riffle habitats. However, few darter species occur in streams of the Lake Agassiz Plain ecoregion. For this reason we replaced the number of darter species metric with three separate metrics (Fig. 5, 6 and 7).

Proportion of Headwater Species

Ohio EPA (1987) and Simon (1991) demonstrated that certain fish assemblages inhabited headwater streams (50 km^2 DA). Ohio EPA (1987) and Simon (1990) designated nine species as headwater taxa. Five species found in the Lake Agassiz Plain were designated as headwater taxa (Table 5). Headwater fish species were associated with stable flow conditions, permanent habitat, low environmental stress and higher biological integrity (Ohio EPA 1987; Simon 1990).

Because the Lake Agassiz Plain ecoregion experiences a wide range of climatic conditions, intensive drought and flooding cycles may occur. Prior to the first year of this study, the Red River Valley and most of North Dakota suffered through a prolonged drought. However, during the study water levels were high. The abundance and composition of headwater species can be directly related to these natural cycles.

Number of Benthic Insectivore Species

The minnows, suckers, and madtoms were benthic insectivores that functionally occupied the same type of niche as the darters (Ohio EPA 1987; Simon 1991). Their inclusion allowed a greater degree of sensitivity in evaluating streams that naturally had few darter species. We designated 19 species to be benthic insectivores (Table 5). Except for blacknose dace, which may be behaviorally plastic (Leonard and Orth 1986), the remainder of the species were found in riffle habitats usually over clean gravel substrates. An increase in benthic insectivore species was correlated with increased biotic integrity.

Benthic insectivores were absent at a significant number of headwater sites. This was a deciding factor for using separate metrics for each drainage size. This metric asymptoted at moderate stream sizes and declined at the largest DA's (Fig. 6)

Proportion of Round-bodied Suckers

The number of sucker species was used in Karr's (1981) IBI. Unlike smaller benthic insectivores which were difficult to collect in large rivers, suckers were effectively sampled with electrofishing gear and comprised a significant component of the large riverine fish fauna. Due to their long life cycles (10-20 years), suckers provided a long term assessment of past environmental conditions. Most sucker species were intolerant to habitat and water quality degradation (Phillips and Underhill 1971; Karr et al. 1986; Trautman 1981; Becker 1983). Their feeding and reproductive requirements were sensitive to turbidity and marginal to poor water quality resulting in sensitivity at the higher end of environmental quality.

We applied the proportion of round-bodied suckers for DA > 1500 mi^2. Round-bodied suckers include members of the sucker genera Minytrema, Hypentelium, Moxostoma, Cycleptus, and Erimyzon (Table 5). We did not include members of the sucker genus Catostomus since members of this genus are able to tolerate a wide variety of environmental perturbations. Of the 9 sucker species present in the Red River Basin, five were considered round bodied (Table 5). The proportion of round-bodied suckers did not show any relationship with DA for large rivers (Fig. 7).

Table 5. List of headwater, benthic insectivore, and round-bodied sucker species in the Lake Agassiz Plain ecoregion.

Common name	Scientific name	Headwater species	Benthic insectivore species	Round-bodied sucker species
Northern hogsucker	Hypentelium nigricans		X	X
Silver redhorse	Moxostoma anisurum		X	X
Golden redhorse	M. erythrurum		X	X
Shorthead redhorse	M. macrolepidotum		X	X
Greater redhorse	M. valenciennesi		X	X
Silver chub	Macrhybopsis storeriana		X	
Bigmouth shiner	Notropis dorsalis		X	
Sand shiner	N. stramineus		X	
Blacknose dace	Rhinichthys atratulus	X	X	
Longnose dace	R. cataractae		X	
Northern redbelly dace	Phoxinus eos	X		
Finescale dace	Phoxinus neogaeus	X		
Pearl dace	Margariscus margarita	X		
Trout-perch	Percopsis omiscomaycus		X	
Rainbow darter	Etheostoma caeruleum		X	
Iowa darter	E. exile		X	
Least darter	E. microperca		X	
Johnny darter	E. nigrum		X	
Logperch	Percina caprodes		X	
Blackside darter	P. maculata		X	
Stonecat	Noturus flavus		X	
Tadpole madtom	N. gyrinus		X	
Brook stickleback	Culaea inconstans	X		

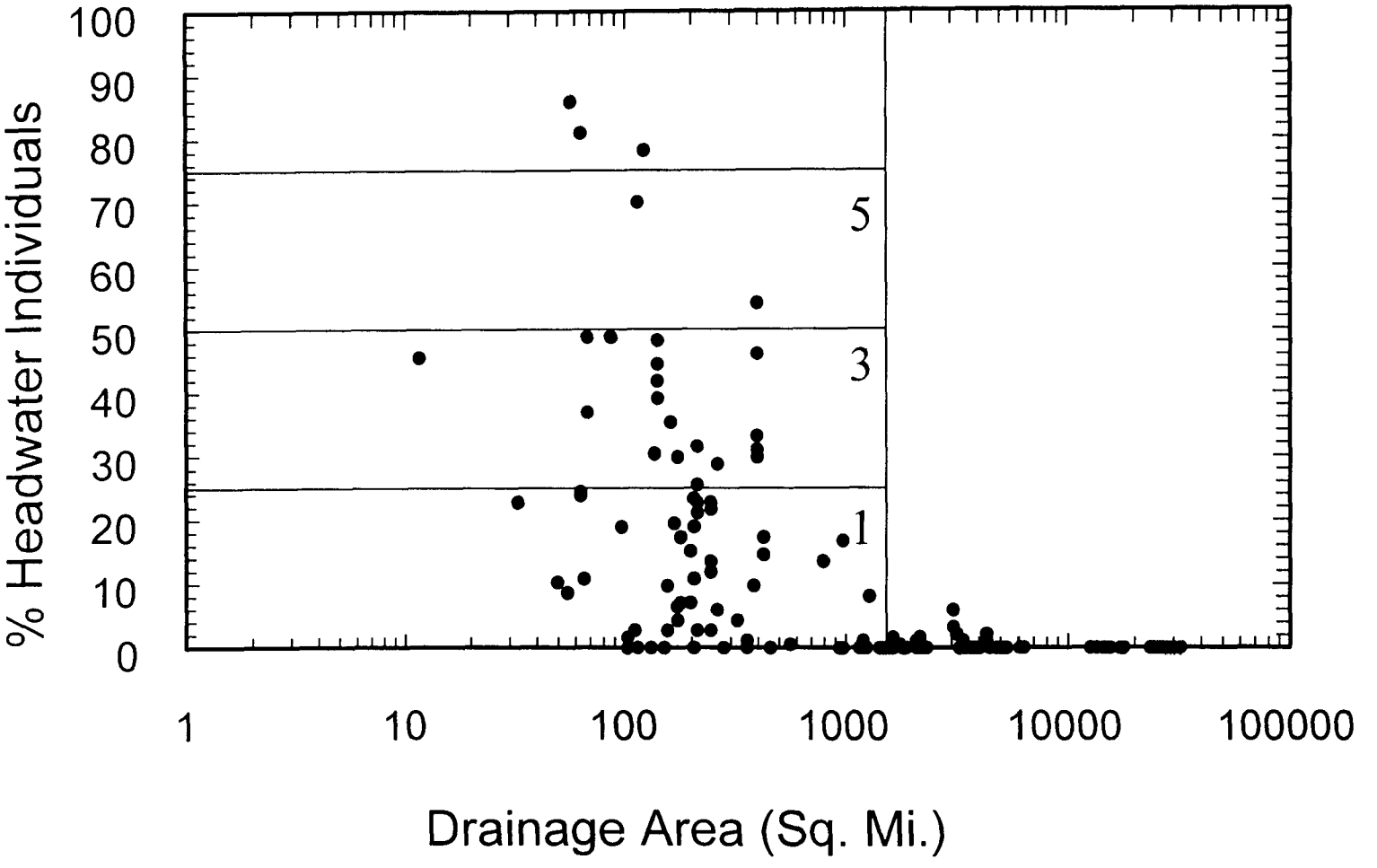

Figure 5: Maximum scoring lines for determining trends in the number of headwater individuals with increasing drainage area for the Lake Agassiz Plain ecoregion.

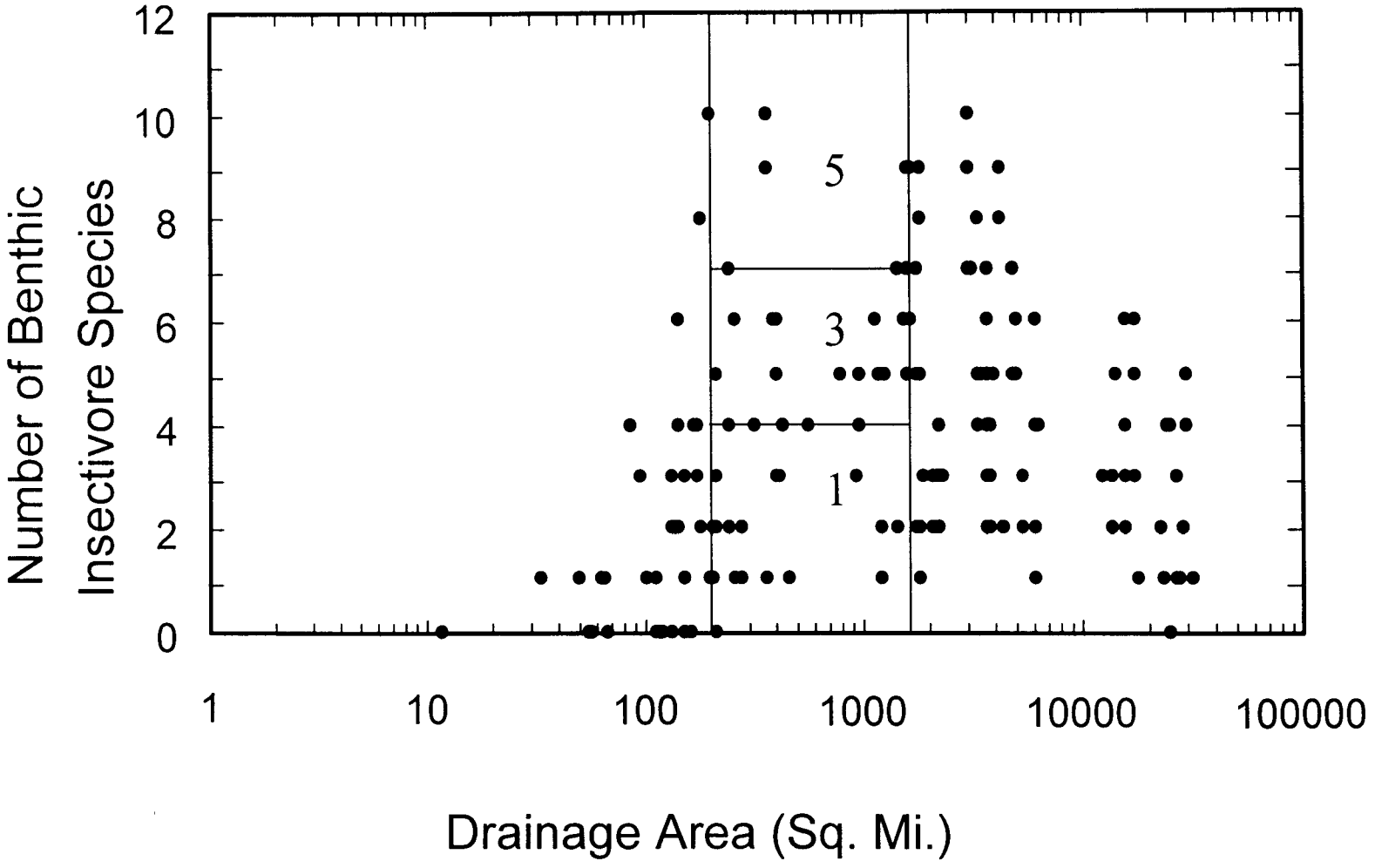

Figure 6: Maximum scoring lines for determining trends in the number of benthic insectivore species with increasing drainage area for the Lake Agassiz Plain ecoregion.

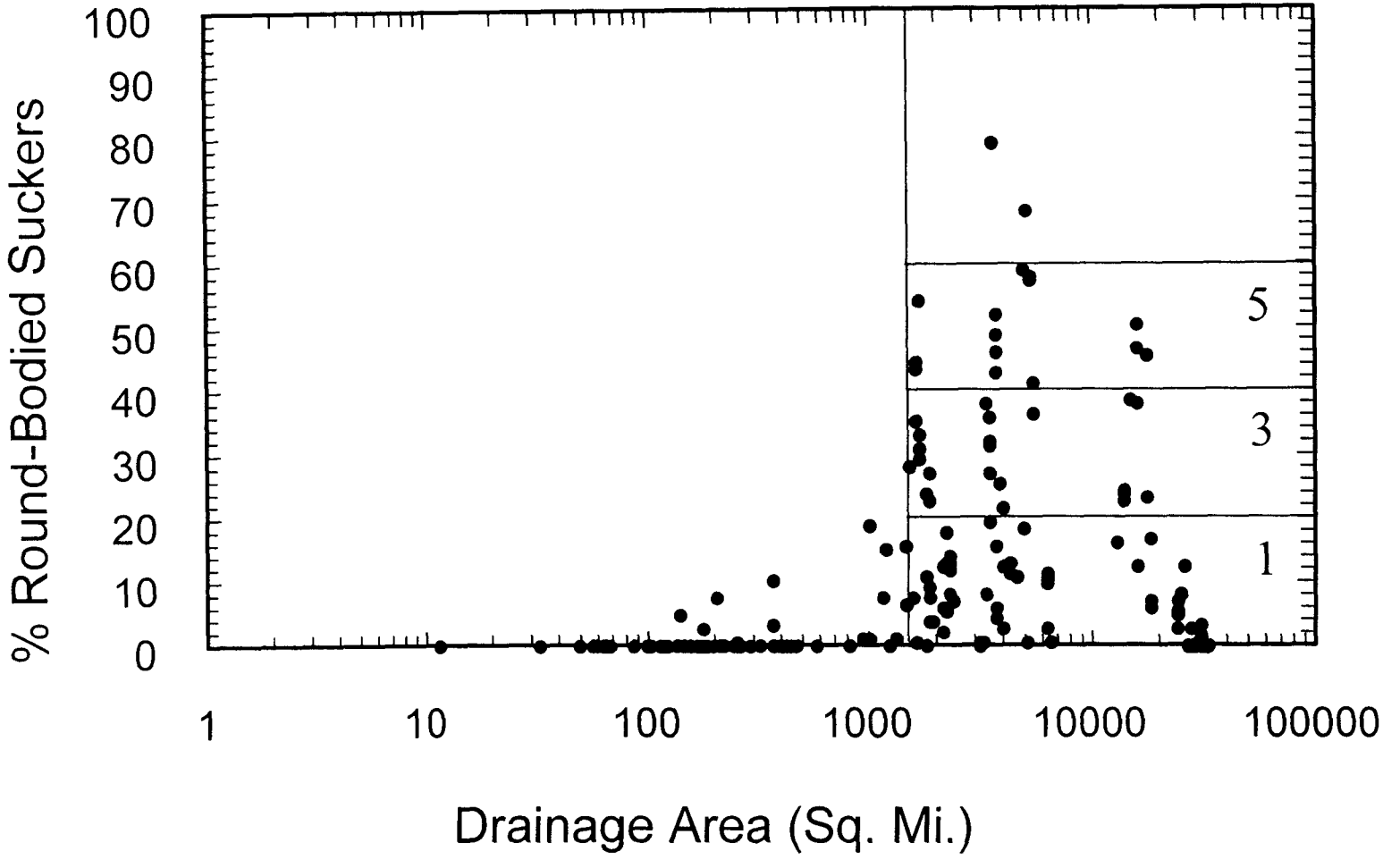

Figure 7: Maximum scoring lines for determining trends in the proportion of round-bodied suckers with increasing drainage area for the Lake Agassiz Plain ecoregion.

Metric 3. Number of Minnow Species (Headwater and Moderate Sized Streams)
Proportion of Large River Individuals (Large Rivers)

Impetus

The number of minnow species replaced the number of sunfish species to evaluate pool habitat quality (Karr 1981). Sunfish were not common in the Lake Agassiz Plain. Instead, a diverse minnow community occupied pool habitats (Table 6). Since minnows were often difficult to collect in large rivers, another metric was substituted for the original sunfish metric proposed by Karr (1981). Although not a complete replacement for the evaluation of pool habitat, the lack of sunfish species in the Lake Agassiz Plain ecoregion facilitated the substitution of the proportion of large river individuals.

Number of Minnow Species

Eleven minnow species occurred in headwater and moderate sized streams. Species including the hornyhead chub Nocomis biguttatus, sand shiner Notropis stramineus, and rosyface shiner N. rubellus were examples of minnows that occurred in high quality areas. Species such as creek chub Semotilus atromaculatus, fathead minnow Pimephales promelas, and golden shiner Notemigonus crysoleucas were tolerant to both chemical degradation and stream desiccation. High numbers of minnow species corresponded with higher biological integrity.

Because many minnow species occupied slower moving pool habitats they may have been exposed to areas that acted as "sinks" for the accumulation of toxins and silt. Thus, this metric measured degradation of rock substrates (i.e. gravel and boulder)(Hughes and Gammon 1987), instream cover (Pflieger 1975; Trautman 1981), and the associated aquatic macroinvertebrate community which was an important food resource (Forbes and Richardson 1920; Becker 1983). Minnows were an important component of the aquatic community to measure because they were wide-ranging and they were susceptible to collection gear in most streams and rivers of Minnesota and North Dakota. The number of minnow species asymptoted at moderate sized streams (Fig. 8).

Proportion of Large River Individuals

Just as darters, madtoms, sculpins, and other benthic insectivores were characteristic of small streams, so certain species were commonly found in large river habitats (Table 7). Pflieger (1975), Burr and Warren (1986), Simon (1992), and Simon and Emery (1995) found that a characteristic fish faunal assemblage was apparent in large and great river habitats. Simon (1992) found that certain fish species such as sturgeon, gar, river shiner, carpsuckers, buffalo, channel catfish, and some chubs appeared at DA's about 2,000 mi^2. The number of large river species in the Lake Agassiz Plain ecoregion was expected to predominate in > 1,500 mi^2 DA. A lower proportion of large river taxa suggested a loss of biological integrity in large river habitats. The proportion of large river individuals in the Lake Agassiz Plain ecoregion increased with DA (Fig. 9).

Table 6. Minnow species from the Lake Agassiz Plain ecoregion of Minnesota and North Dakota used for evaluating quality pool habitat.

Common name	Scientific name
Central stoneroller	Campostoma anomalum
Largescale stoneroller	C. oligolepis
Spotfin shiner	Cyprinella spiloptera
Carp	Cyprinus carpio
Brassy minnow	Hybognathus hankinsoni
Common shiner	Luxilus cornutus
Silver chub	Macrhybopsis storeriana
Flathead chub	M. gracilis
Pearl dace	Margariscus margarita
Hornyhead chub	Nocomis biguttatus
Golden shiner	Notemigonus crysoleucas
Pugnose shiner	Notropis anogenus
Emerald shiner	N. antherinoides
River shiner	N. blennius
Bigmouth shiner	N. dorsalis
Blackchin shiner	N. heterodon
Blacknose shiner	N. heterolepis
Spottail shiner	N. hudsonius
Sand shiner	N. ludibundus
Rosyface shiner	N. rubellus
Weed shiner	N. texanus
Mimic shiner	N. volucellus
Northern redbelly dace	Phoxinus eos
Finescale dace	P. neogaeus
Bluntnose minnow	Pimephales notatus
Fathead minnow	P. promelas
Blacknose dace	Rhinichthys atratulus
Longnose dace	R. cataractae
Creek chub	Semotilus atromaculatus

Table 7. Minnesota and North Dakota species considered large river taxa following Pflieger (1975) and Simon and Emery (1995).

Common name	Scientific name
Chestnut lamprey	Ichthyomyzon castaneus
Silver lamprey	I. unicuspis
Mooneye	Hiodon tergisus
Goldeye	H. alosoides
Quillback	Carpiodes cyprinus
Bigmouth buffalo	Ictiobus cyprinellus
Greater redhorse	Moxostoma valenciennesi
Silver chub	Macrhybopsis storeriana
Emerald shner	Notropis atherinoides
Spottail shiner	N. hudsonius
Channel catfish	Ictalurus punctatus
Burbot	Lota lota
White bass	Morone chrysops
Sauger	Stizostedion canadense
Walleye	S. vitreum
Freshwater drum	Aplodinotus grunniens

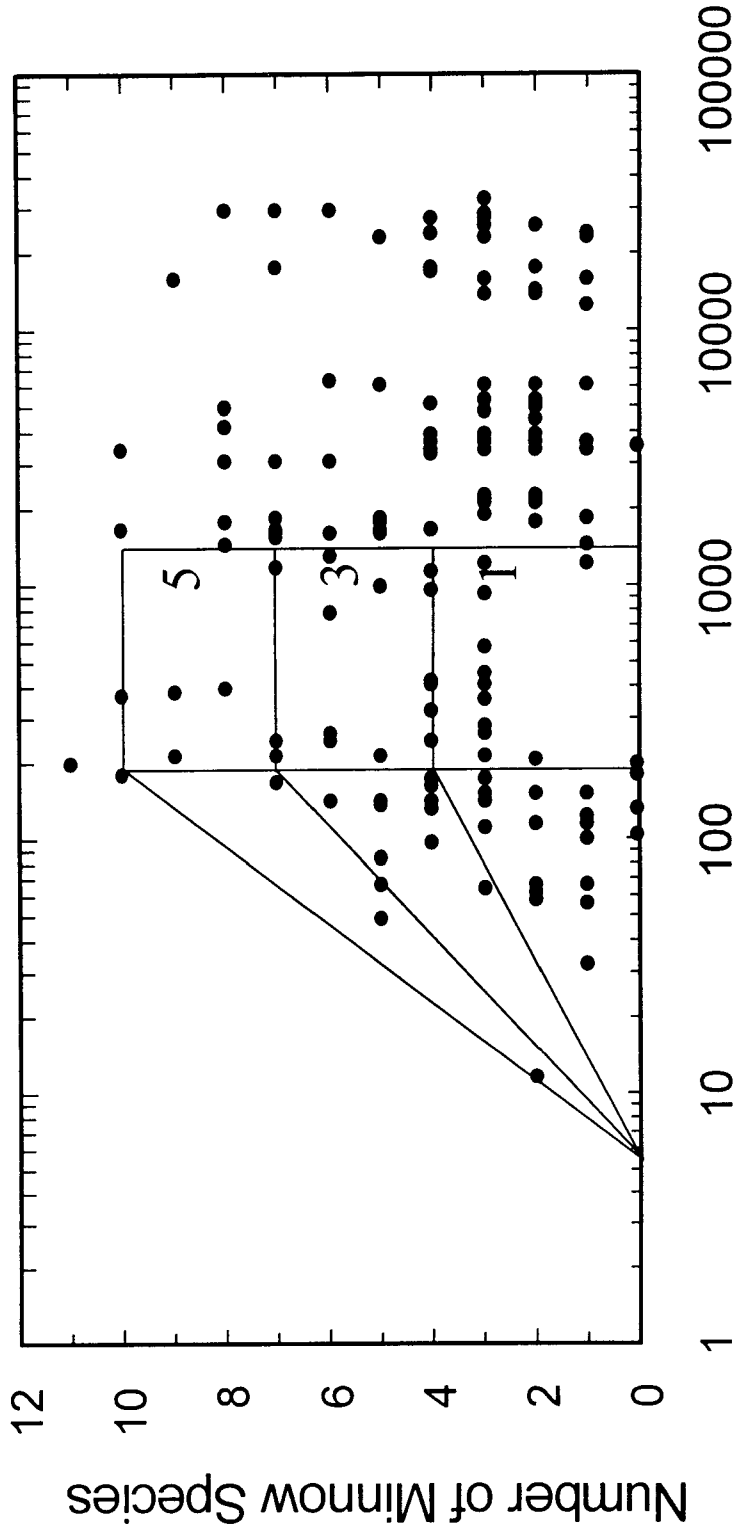

Figure 8: Maximum species richness lines for determining trends in the number of minnow species with increasing drainage area for the Lake Agassiz Plain ecoregion.

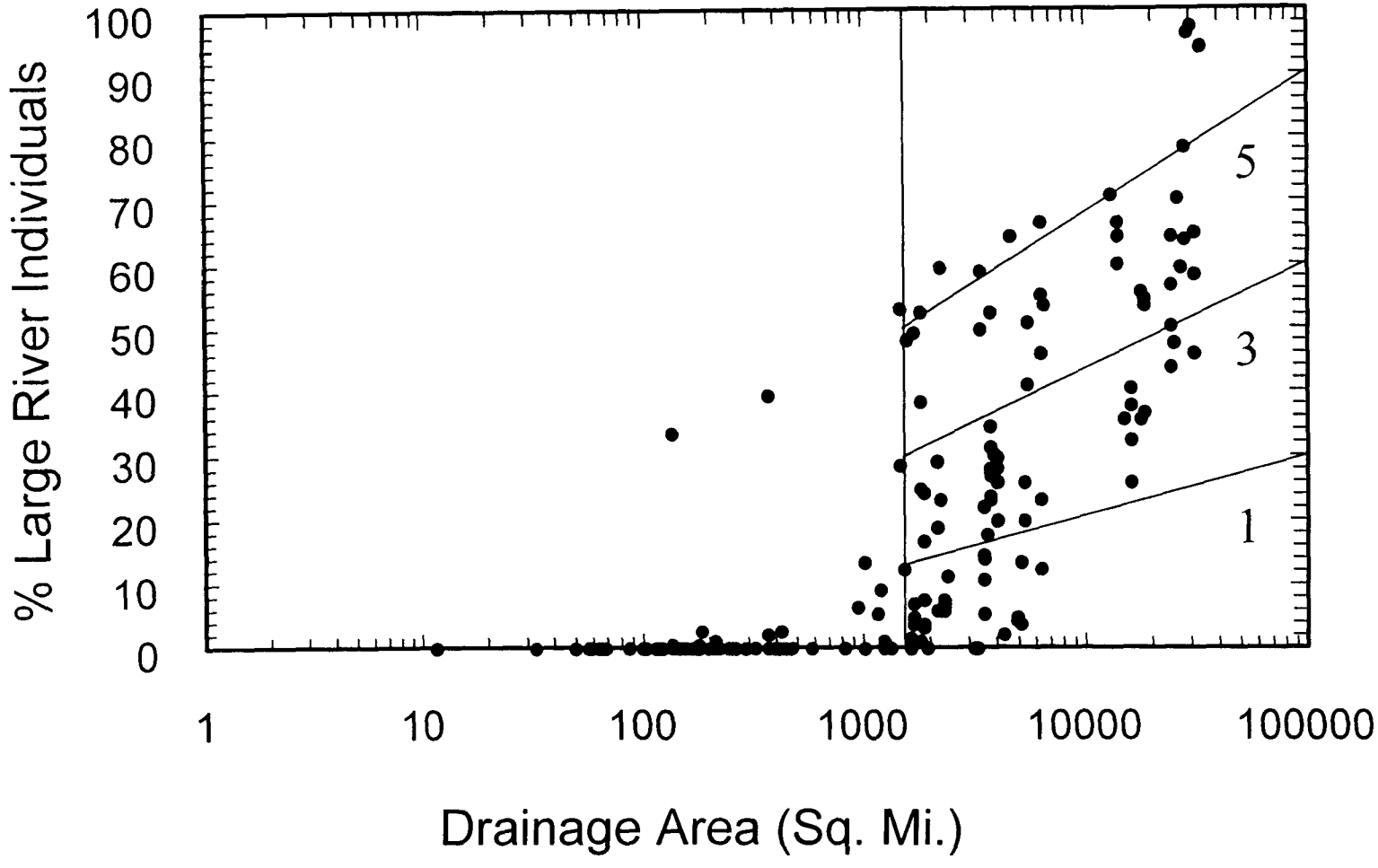

Figure 9: Maximum scoring lines for determining trends in proportion of large river individuals with increasing drainage area for the Lake Agassiz Plain ecoregion.

Metric 4. Evenness (All Streams and Rivers)

Impetus

Evenness described the distribution of abundance of individuals among species by comparing the observed diversity to a theoretical maximum (Pielou, 1975). If all species had equal abundance, the distribution of abundances had maximum evenness (value = 1). The greater the differences in abundance, the smaller the evenness (value approaches 0).

In many cases where environmental degradation has occurred, one species in the community will dominate while the other species decline. Those species with the capacity to capitalize on a physical or chemical change in their environment were usually tolerant species. In the case of a stream where degradation had allowed tolerant or exotic species to increase in abundance to the detriment of other species, evenness would have decreased as the proportion of tolerant species increased. Using evenness as a metric complimented the tolerant species metric by providing a measure of the degree that tolerant species dominated a particular environment. Thus, reduced evenness indicated a loss of biotic integrity.

No drainage relationship was observed for this metric (Fig. 10). We did not expect any relationship since this community attribute was not influenced by stream size categories but disruptions in community stability.

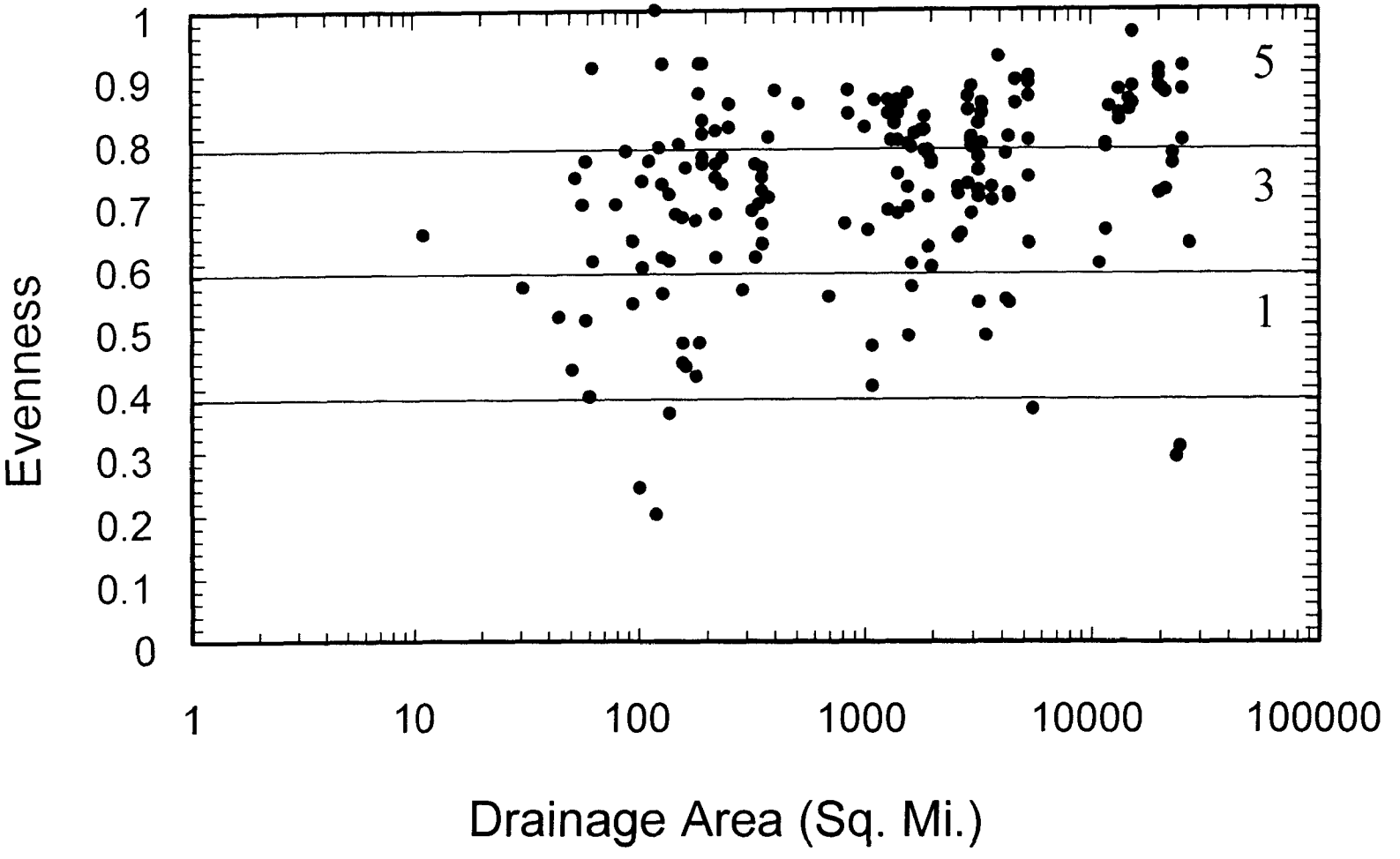

Figure 10: Maximum scoring lines for determining trends in evenness with increasing drainage area for the Lake Agassiz Plain ecoregion.

Metric 5. Number of Sensitive Species (All Streams and Rivers)

Impetus

Karr's (1981) original metric, the number of intolerant species, included only those species that were considered highly intolerant to a variety of disturbances. Karr et al. (1986) further defined intolerant taxa as those that declined with decreasing environmental quality and disappeared when the aquatic environment degraded to fair (Karr et al. 1986). Because very few species at headwater sites were classified as highly intolerant, Ohio EPA (1987) modified the intolerant species metric to include some species classified as moderately intolerant. This modified version of Karr's original intolerant metric was called the sensitive species metric.

The criteria for determining intolerance for the Lake Agassiz Plain was based on numerical and graphical analysis of Ohio's regional data base, Underhill's (1989) documentation of historical changes in the distribution of Minnesota species, and supplemental information from regional ichthyofaunal texts (Pflieger 1975; Smith 1979; Trautman 1981; Becker 1983; Burr and Warren 1986). The number of sensitive species distinguished between streams of highest quality. Designation of too many species as sensitive prevented this metric from discriminating among the highest quality resources. An absence of sensitive species indicated an anthropogenic stress or loss of habitat. Until improvements in water quality warrant it, the sensitive species metric (Ohic EPA 1987) should be retained for all headwater, moderate sized streams, and large rivers in the Lake Agassiz Plain. Sensitive species increased with DA among headwater and moderate sized streams and asymptoted in large rivers (Fig. 11).

Table 8. Fish species found in the Lake Agassiz Plain of Minnesota and North Dakota that are considered to be sensitive to environmental disturbances including water quality and habitat degradation .

Common name	Scientific name
Goldeye	Hiodon alosoides
Mooneye	H. tergisus
Hornyhead chub	Nocomis biguttatus
Pugnose shiner	Notropis anogenus
Blacknose shiner	N. heterodon
Blackchin shiner	N. heterolepis
Sand shiner	N. ludibundis
Rosyface shiner	N. rubellus
Mimic shiner	N. volucellus
N. Redbelly dace	Phoxinus eos
Finescale dace	P. neogenus
Longnose dace	Rhinichthys cataractae
Northern hogsucker	Hypentelium nigricans
Silver redhorse	Moxostoma anisurum
Golden redhorse	M. erythurum
Shorthead redhorse	M. macrolepidotum
Greater redhorse	M. valenciennesi
Stonecat	Noturus flavus
Trout-perch	Percopsis omiscomaycus
Rock bass	Ambloplites rupestris
Smallmouth bass	Micropterus dolomieui
Rainbow darter	Etheostoma caeruleum
Logperch	Percina caprodes

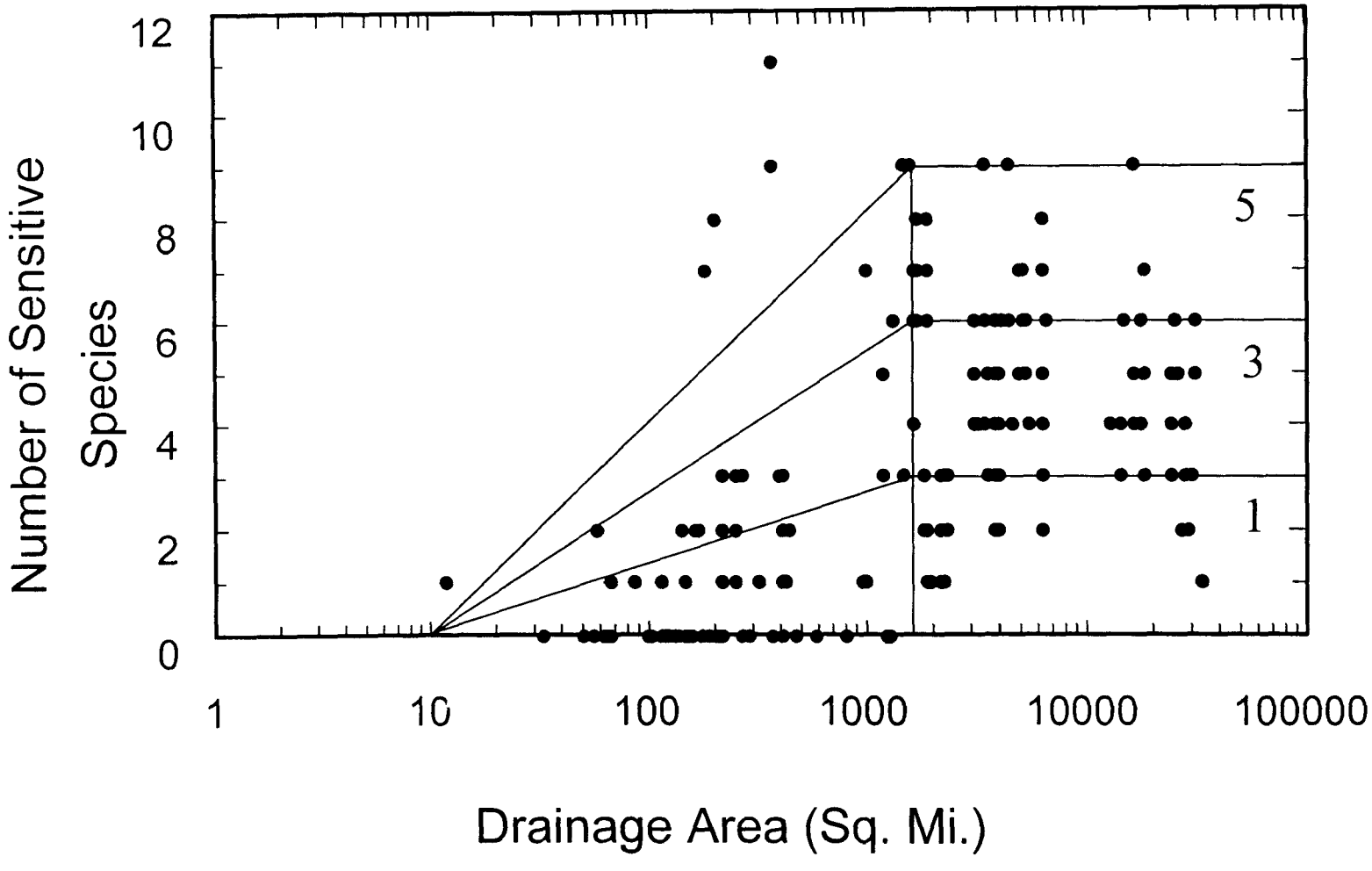

Figure 11: Maximum scoring lines for determining trends in number of sensitive species with increasing drainage area for the Lake Agassiz Plain ecoregion.

Metric 6. Proportion of Tolerant Individuals (All Streams and Rivers)

Impetus

Karr's (1981) original IBI included the percentage of the fish community comprised of green sunfish, Lepomis cyanellus. The green sunfish was often present in moderate numbers in many Midwest streams and became dominant in cases of degradation or poor water quality. Competitive advantage in disturbed environments enabled the green sunfish to survive and reproduce even under degraded conditions. Although the green sunfish was widely distributed in the Midwest, it was most commonly collected in headwater streams. This introduced bias for moderate sized streams to large rivers. Karr et al. (1986) suggested additional species that could be substituted for the green sunfish. Several species in the Lake Agassiz Plain were known to increase in abundance along with increasing degradation of stream quality (Table 9). By increasing the number of species in this metric the sensitivity for different sized streams and rivers was improved. This metric detected a decline in stream quality from fair to poor.

Tolerant species designations were based on Ohio EPA (1989) and expert consensus between Minnesota and North Dakota ichthyologists. Tolerant species were tolerant to thermal loadings, siltation, habitat degradation, and certain toxins (Gammon 1983; Ohio EPA 1989).

No DA relationship was evident for small streams. However, a negative DA relationship was observed in large rivers (> 1500 mi^2) (Fig. 12).

Table 9. Fish species found in the Lake Agassiz Plain ecoregion of Minnesota and North Dakota that were considered to be highly tolerant to environmental disturbances including water quality and habitat degradation.

Common name	Scientific name
Central mudminnow	Umbra limi
Carp	Cyprinus carpio
Golden shiner	Notemigonus crysoleucas
Bluntnose minnow	Pimephales notatus
Fathead minnow	P. promelas
Blacknose dace	Rhinichthys atratulus
Creek chub	Semotilus atromaculatus
Quillback	Carpiodes cyprinus
Bigmouth buffalo	Ictiobus cyprinellus
White sucker	Catostomus commersoni
Channel catfish	Ictalurus punctatus
Black bullhead	Amieurus melas
Freshwater drum	Aplodinotus grunniens
Green sunfish	Lepomis cyanellus
Brook stickleback	Culaea inconstans

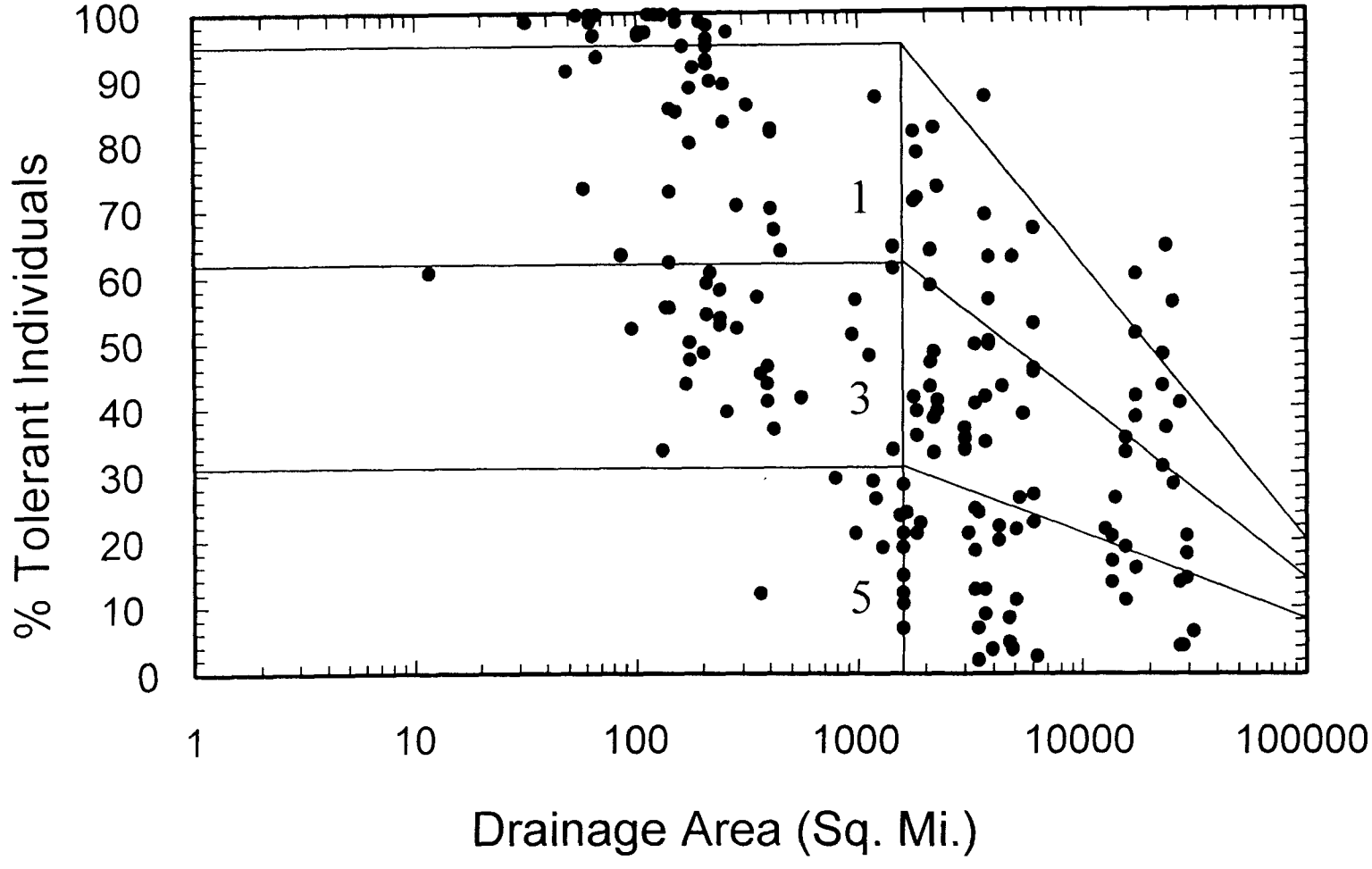

Figure 12: Maximum scoring lines for determining trends in proportion of tolerant individuals with increasing drainage area for the Lake Agassiz Plain ecoregion.

Metric 7. Proportion of Omnivore Biomass (All Streams and Rivers)

Impetus

Omnivorous fish species consume significant quantities of both plant and animal materials (including detritus) and have the physiological ability (usually indicated by the presence of a long coiled gut and dark peritoneum) to utilize both (Goldstein et al. 1994). Fishes that do not feed on plants but on a variety of animal material are not considered omnivores.

Dominance of omnivores suggested specific components of the food base were less reliable, increasing the success of more opportunistic species. Specialized filter-feeders were not included in this metric since these species were sensitive to environmental degradation, e.g. paddlefish, Polyodon spathula and lamprey ammocoetes, Lampetra and Ichthyomyzon (Ohio EPA 1989). Facultative species that shift diet due to degraded environmental conditions were also not considered omnivores, e.g. Semotilus atromaculatus and Rhinichthys atratulus. The bullheads (Ameiurus spp) were considered omnivorous. Although bullheads did not possess a dark peritoneum and therefore did not fit the above definition of an omnivore, the professional opinion of local biologists was that the bullheads function as omnivorous members of the fish community in the Lake Agassiz Plain ecoregion. This metric evaluated the intermediate to low categories of environmental quality (Table 10).

We chose to use the proportion of omnivore biomass rather than percentage of individuals since biomass more appropriately reflected the utilization of energy within the fish community. These values differed from the omnivore percentages of Karr et al. (1986) that was based on the number of individuals, but resemble Ohio EPA's (1987) classification. No relationship with DA was found for headwater, moderate streams, or large river sites (Fig. 13).

Table 10. List of Minnesota and North Dakota fish species considered to be omnivores.

Common name	Scientific name
Carp	Cyprinus carpio
Pugnose shiner	Notropis anogenus
Bluntnose minnow	Pimephales notatus
Fathead minnow	P. promelas
Quillback	Carpiodes cyprinus
White sucker	Catostomus commersoni
Bigmouth buffalo	I. cyprinellus
Brown bullhead	Ameiurus nebulosus
Yellow bullhead	A. natalis
Black bullhead	A. melas

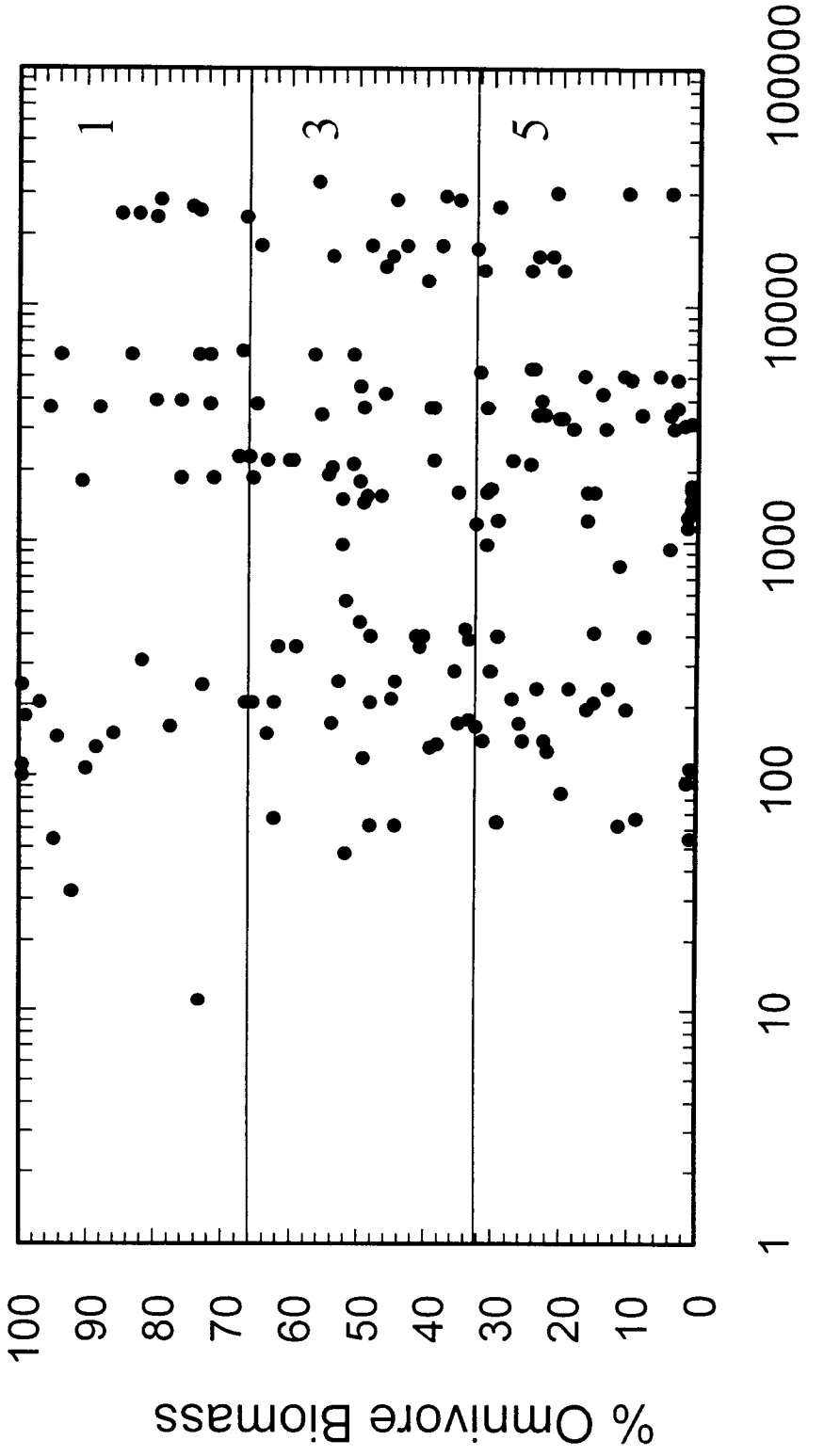

Figure 13: Maximum scoring lines for determining trends in proportion of omnivore biomass with increasing drainage area for the Lake Agassiz Plain ecoregion.

Metric 8. Proportion of Insectivore Biomass (All Streams and Rivers)

Impetus

The original IBI included the proportion of insectivorous cyprinidae (Karr et al. 1986). Insectivorous species are an important link in transferring energy between lower trophic levels to keystone predator species. This metric was intended to respond to a depletion of the benthic macroinvertebrate community that comprised the primary food base for most insectivorous fishes. As disturbance increased, the diversity of insect larvae decreased, triggering an increase in the omnivorous trophic level. Thus, this metric varied inversely with the omnivore metric with increased environmental degradation. The inclusion of all insectivorous species (Table 11) was based on the observation that not all regions of Minnesota and North Dakota possess high proportions of insectivorous cyprinids in high quality streams. There was no DA relationship with the proportion of insectivorous fishes in the Lake Agassiz Plain ecoregion (Fig. 14).

Table 11. Minnesota and North Dakota species considered to be insectivores.

Common name	Scientific name
Goldeye	Hiodon alosoides
Mooneye	H. tergisus
Silver redhorse	Moxostoma anisurum
Golden redhorse	M. erythrurum
Shorthead redhorse	M. macrolepidotum
Greater redhorse	M. valenciennesi
Northern hogsucker	Hypentelium nigricans
Longnose dace	Rhinichthys cataractae
Blacknose dace	R. atratulus
Northern redbelly dace	Phoxinus eos
Finescale dace	P. neogaeus

Table 11. (Continued)

Common name	Scientific name
Pearl dace	Margaricus margarita
Flathead chub	Macrhybopsis gracilis
Silver chub	M. storeriana
Horneyhead chub	Nocomis biguttatus
Creek chub	Semotilus atromaculatus
Golden shiner	Notemigonus crysoleucas
Spottail shiner	Notropis hudsonius
Bigmouth shiner	N. dorsalis
River shiner	N. blennius
Rosyface shiner	N. rubellus
Blackchin shiner	N. heterodon
Blacknose shiner	N. heterolepis
Weed shiner	N. texanus
Sand shiner	N. ludibundus
Mimic shiner	N. volucellus
Emerald shiner	N. atherinoides
Common shiner	Luxilus cornutus
Spotfin shiner	Cyprinella spiloptera
Stonecat	Noturus flavus
Tadpole madtom	N. gyrinus
Central mudminnow	Umbra limi
Freshwater drum	Aplodinotus grunniens
Yellow perch	Perca flavescens
Blackside darter	Percina maculata
Logperch	P. caprodes
Iowa darter	Etheostoma exile
Rainbow darter	E. caeruleum
Least darter	E. microperca
Johnny darter	E. nigrum
Green sunfish	Lepomis cyanellus
Bluegill	L. macrochirus
Orangespotted sunfish	L. humilus
Pumpkinseed	L. gibbosus
Brook stickleback	Culaea inconstans
Trout-perch	Percopsis omiscomaycus

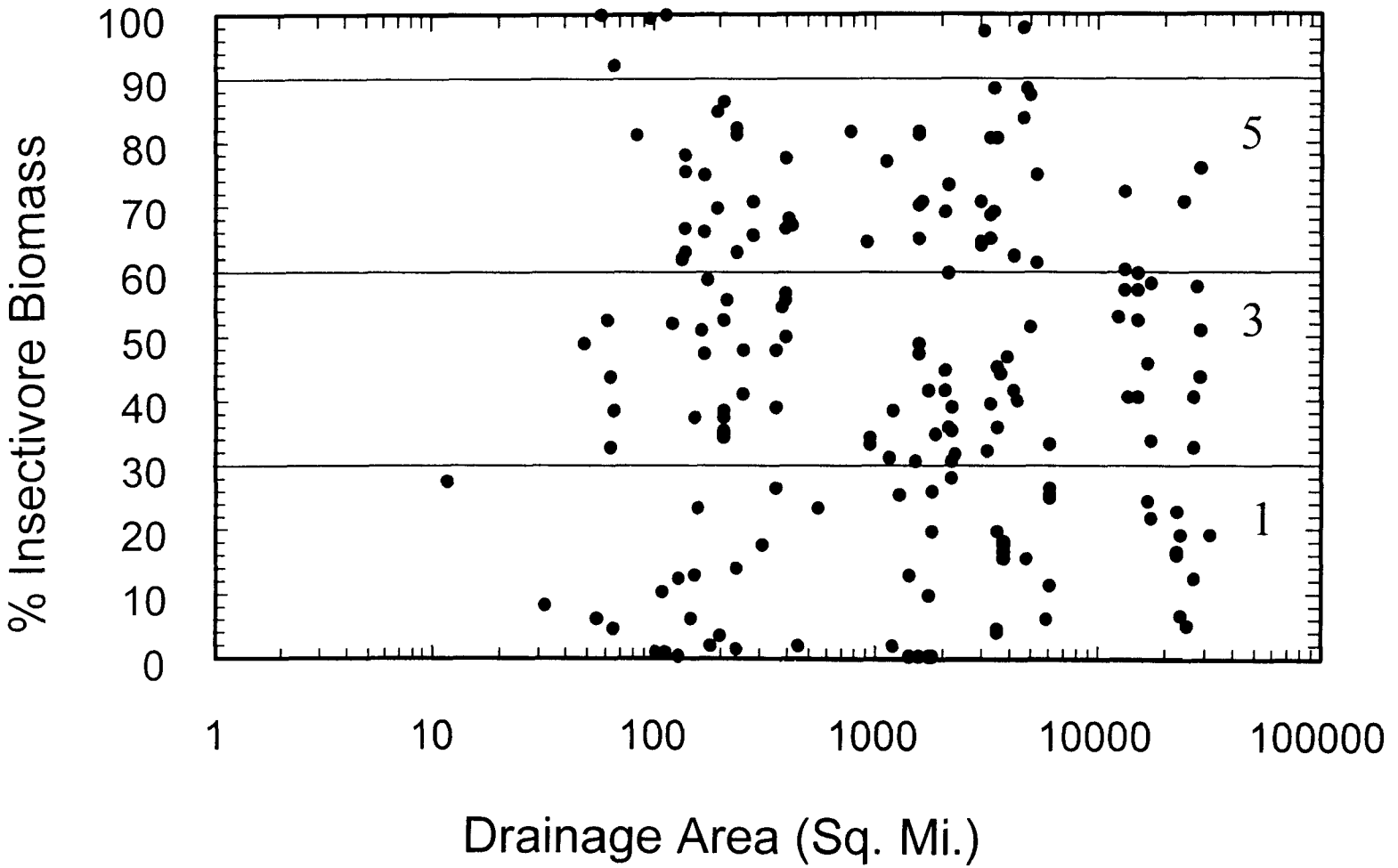

Figure 14: Maximum scoring lines for determining trends in proportion of insectivore biomass with increasing drainage area for the Lake Agassiz Plain ecoregion.

Metric 9. Proportion of Pioneer Species (Headwater Streams)
Proportion of Piscivore Biomass (Moderate Sized Streams and Large Rivers)

Impetus

Karr (1981) developed the carnivore metric to measure community integrity in the upper trophic levels of the fish community. It is only in high quality environments that species occupying the upper trophic levels were able to flourish.

Proportion of Pioneer Species

Piscivores were generally not abundant in headwater streams. An alternate metric was developed by Ohio EPA (1987) to determine the permanence of the stream habitat. Smith (1971) identified a signature assemblage of small stream species that he called "pioneer species" (Table 12). These species were the first to colonize sections of headwater streams after desiccation and also tended to predominate in unstable environments affected by anthropogenic stresses. Thus, a high proportion of pioneer species indicated an environment that was unstable or stressed. The metric was negatively associated with increases in DA (Fig. 15).

Proportion of Piscivore Biomass

This metric included species in which the adults are predominantly piscivores, although some may feed on other vertebrates or invertebrates such as crayfish (Karr et al. 1986). Species that are opportunistic do not fit into this metric, e.g. creek chub (Karr et al. 1986; Ohio EPA 1987).

Karr (1981) suggested that the proportion of piscivores should be related to DA. Such a correlation was not found in the Lake Agassiz Plain ecoregion (Fig. 16). Piscivore species found in the Lake Agassiz Plain ecoregion were listed in Table 13. Because most piscivores found in this region were managed for sportfishing, the natural balance or proportion of piscivores sometimes outweighed other species. Therefore, the metric has an upper limit of 30% piscivore biomass.

Table 12. Pioneer species of the Lake Agassiz Plain ecoregion that are considered to be indicators of temporally unavailable or desiccated habitats (Larimore and Smith 1963; Smith 1971).

Common name	Scientific name
Central stoneroller	Campostoma anomalum
Largescale stoneroller	C. oligolepis
Bluntnose minnow	Pimephales notatus
Fathead minnow	P. promelas
Creek chub	Semotilus atromaculatus
Green sunfish	Lepomis cyanellus
Johnny darter	Etheostoma nigrum

Table 13. Fish species of the Lake Agassiz Plain ecoregion that are piscivores.

Common name	Scientific name
Silver lamprey	Ichthyomyzon unicuspis
Chestnut lamprey	I. castaneus
Northern pike	Esox lucius
Muskellunge	E. masquinongy
White bass	Morone chrysops
Rock bass	Ambloplites rupestris
Smallmouth bass	Micropterus dolomieui
Largemouth bass	M. salmoides
Walleye	Stizostedion vitreum
Sauger	S. canadense
Burbot	Lota lota
Channel catfish	Ictalurus punctatus
Bowfin	Amia calva
Black crappie	Pomoxis nigromaculatus
White crappie	P. annularis

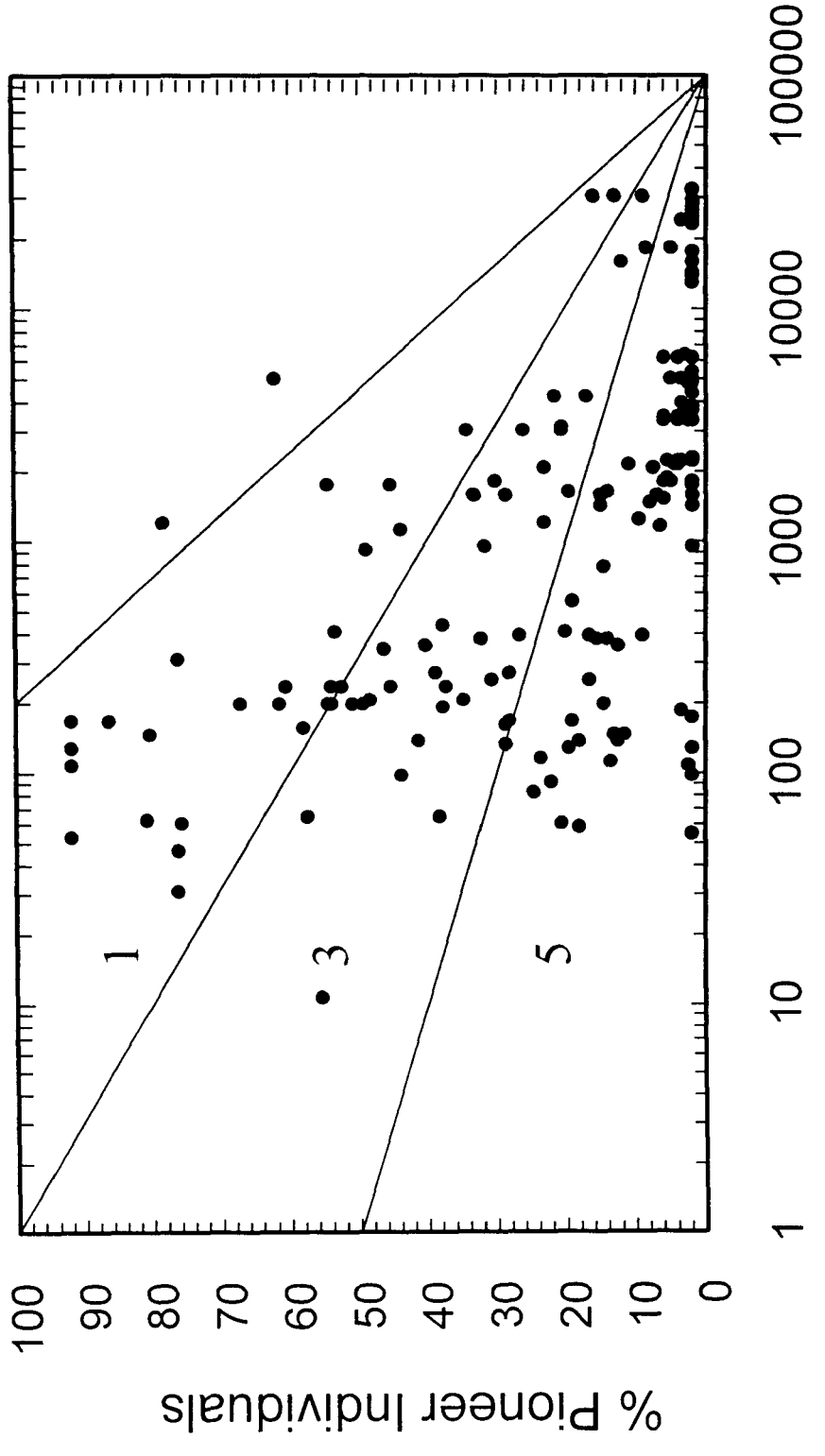

Figure 15: Maximum scoring lines for determining trends in proportion of pioneer individuals with increasing drainage area for the Lake Agassiz Plain ecoregion.

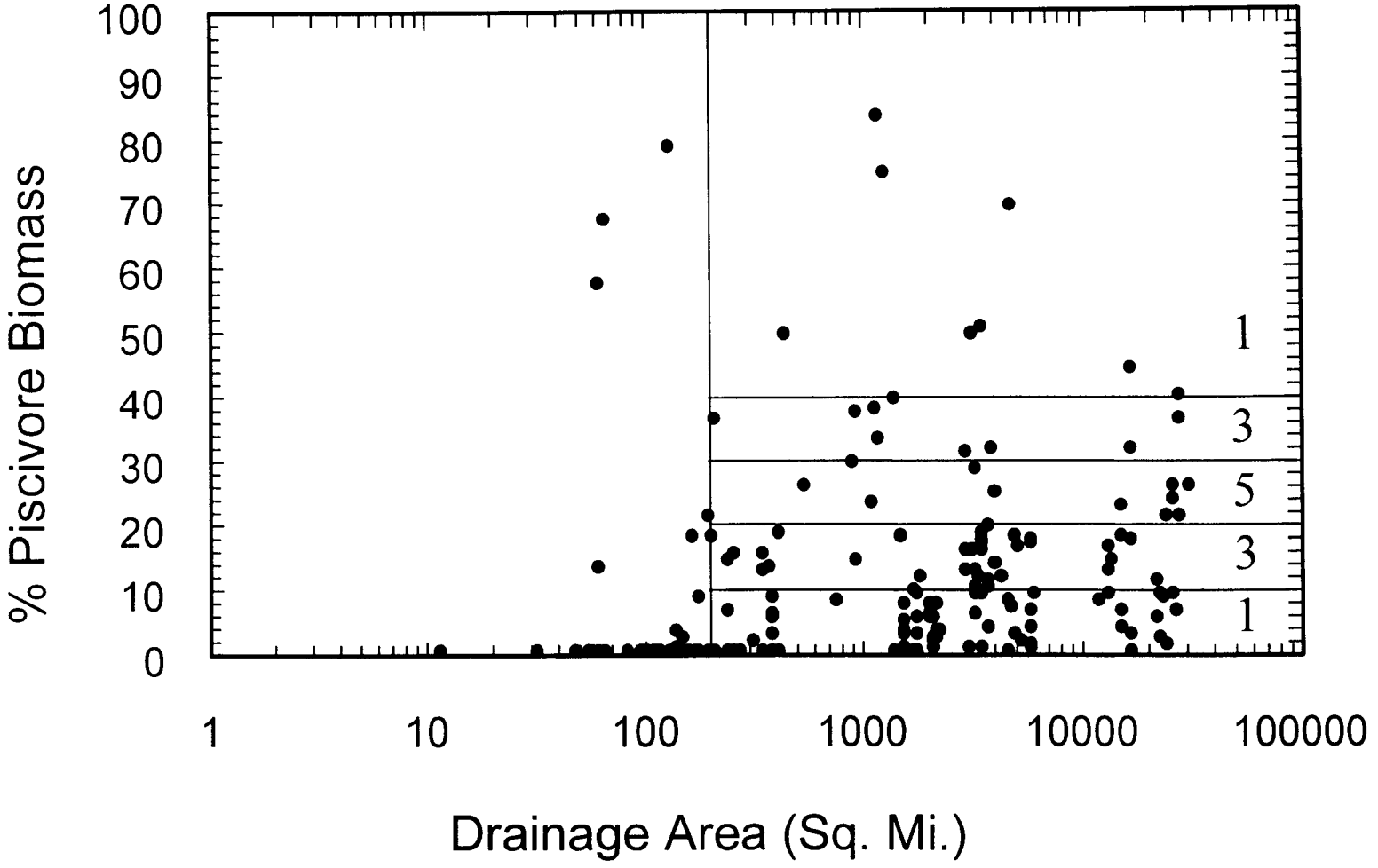

Figure 16: Maximum scoring lines for determining trends in proportion of piscivore biomass with increasing drainage area for the Lake Agassiz Plain ecoregion.

Metric 10. Number of Individuals per Meter (All Streams and Rivers)

Impetus

This metric evaluated population density and was expressed as catch-per-unit of effort. Effort may be defined as the length of stream reach sampled, unit of area sampled, or unit time spent sampling. Low catch-per-unit effort values indicated that biotic integrity was being compromised and that the normal trophic relationship of fish communities was being altered. Although biotic integrity was generally considered to be positively correlated with catch per unit effort, numerous exceptions existed. For instance, as biotic integrity increased, the catch-per-unit effort often became more variable because numerous physical and chemical characteristics of the stream began to limit species abundance. Also, under certain circumstances (*e.g.* channelization) reduced canopy cover increased stream productivity by allowing light to penetrate to the stream surface. This may have lead to an increase in the abundance of certain tolerant fishes (Ohio EPA 1987). Lyons (1992) found that abundance, excluding tolerant species, was greatest at fair quality sites in Wisconsin warmwater streams and lower at sites classified as excellent. Karr et al. (1986) suggested that this metric was most sensitive at intermediate to low ends of the sensitivity continuum.

For the Lake Agassiz Plain ecoregion, catch-per-unit effort was calculated as the total number of individuals collected per meter of stream reach sampled. (See materials and methods, community analysis, sample considerations). A DA-dependent relationship was observed for the Lake Agassiz Plain ecoregion (Fig. 17).

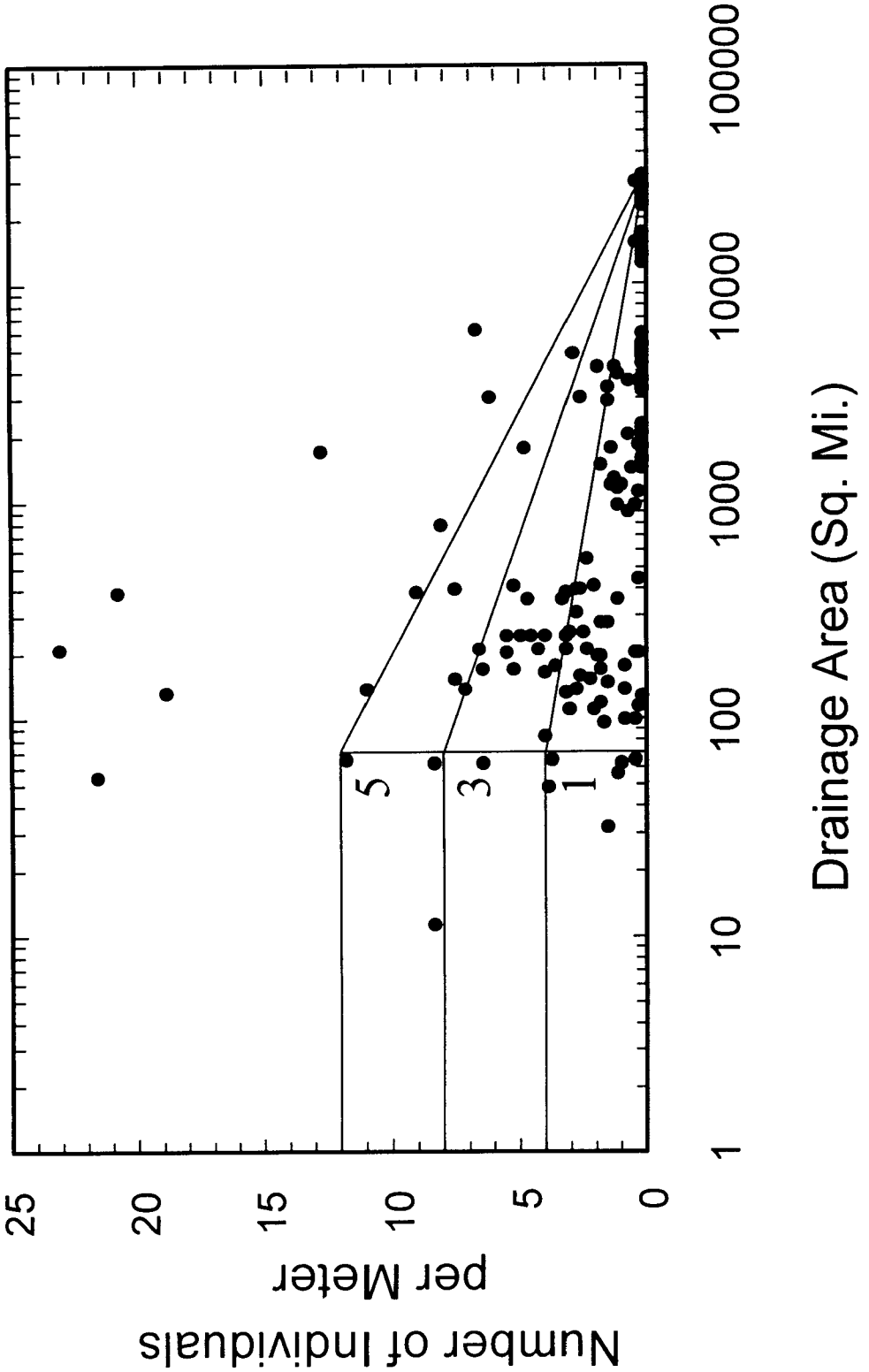

Figure 17: Maximum scoring lines for determining trends in the number of individuals per meter with increasing drainage area for the Lake Agassiz Plain Ecoregion.

Metric 11. Proportion of Individuals as Simple Lithophilic Spawners (All Streams)

Impetus

Ohio EPA (1987) replaced the original metric, proportion of hybrids (Karr et al. 1986), with this metric. The original intent of the hybrid metric was to assess the extent to which degradation had altered reproductive isolation among species. However, difficulties of identification, lack of occurrence in headwater and impacted streams, and presence of hybrids in high quality streams, (e.g., cyprinids and centrarchids) caused this metric to be rather insensitive.

The spawning guild concept has been suggested to be an important metric (Angermeier and Karr 1986). The success of certain spawning guilds may be affected by habitat quality (Balon 1975; Berkman and Rabeni 1987). Simple spawning behavior (i.e. lithophilous) requires clean gravel or cobble for success and may be the most environmentally sensitive (Ohio EPA 1987). Simple lithophils (Table 14) broadcast eggs that come into contact with the substrate. Eggs develop in the interstitial spaces between sand, gravel, and cobble without parental care. Simple lithophils that do not require clean substrates for reproduction were not included in this metric. These species have rapidly developing eggs and larvae that are buoyant or phototaxic and require minimal contact with the substrate.

Simple lithophils were sensitive to environmental disturbance, particularly siltation. Berkman and Rabeni (1987) observed a negative relationship between simple lithophilic spawners and the proportion of silt in streams. Historically, some simple lithophilic spawners have experienced significant range reductions due to increased silt loads in streams. The proportion of lithophilic species was not related to DA (Fig. 18).

Table 14. Species in the lake Agassiz Plain ecoregion that are considered to be simple lithophilic spawners.

Common name	Scientific name
River shiner	N. blennius
Rosyface shiner	N. rubellus
Northern redbelly dace	Phoxinus eos
Blacknose dace	Rhinichthys atratulus
Longnose dace	R. cataractae
White sucker	Catostomus commersoni
Northern hogsucker	Hypentilium nigricans
Silver redhorse	Moxostoma anisurum
Golden redhorse	M. erythrurum
Shorthead redhorse	M. macrolepidotum
Greater redhorse	M. valenciennesi
Burbot	Lota lota
Rainbow darter	Etheostoma caeruleum
Logperch	Percina caprodes
Blackside darter	P. maculata
Sauger	Stizostedion canadense
Walleye	S. vitreum

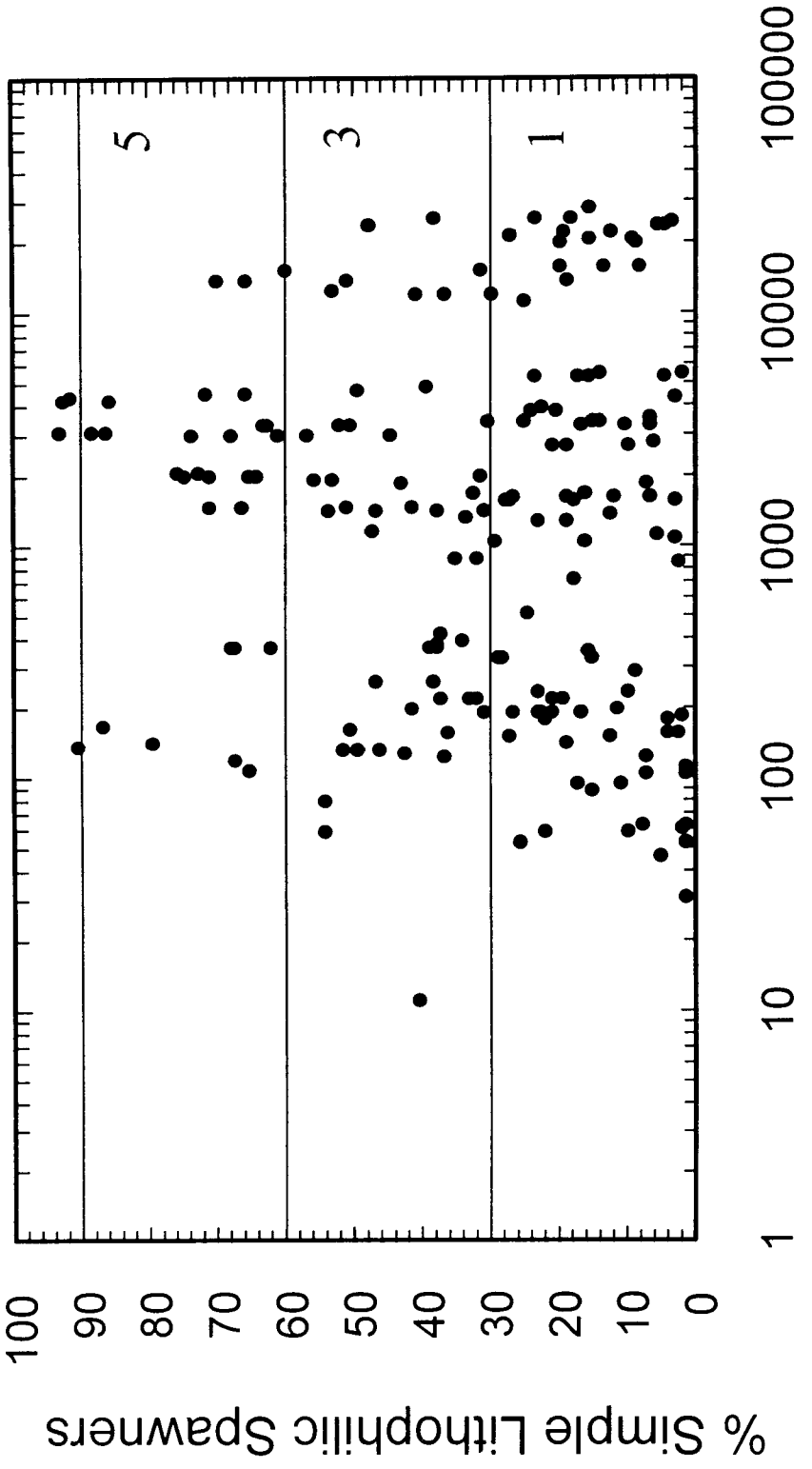

Figure 18: Maximum scoring lines for determining trends in proportion of simple lithophilic spawners with increasing drainage area for the Lake Agassiz Plain ecoregion.

Metric 12. Proportion of Individuals with Deformities, Eroded Fins, Lesions and Tumors (DELT) (All Streams)

Impetus

This metric evaluated the condition of fish based on the percentage of external anomalies such as deformities, eroded fins, lesions, and tumors (DELT). The proportion of individuals with DELT anomalies corresponded to the percentage of diseased fish in Karr's (1981) original index. Studies of fish populations indicated that these anomalies were either absent or occurred at very low rates naturally, but reached higher percentages at impacted sites (Mills et al. 1966; Berra and Au 1981; Baumann et al. 1987). Common causes for DELT anomalies were bacterial, fungal, viral, and parasitic infections, neoplastic diseases, and chemicals (Allison et al. 1977; Post 1983; Ohio EPA 1987). An increase in the frequency of occurrence of these anomalies was an indication of physiological stress due to environmental degradation, chemical pollutants, overcrowding, improper diet, excessive siltation, and other perturbations. In Ohio, the highest incidence of deformities, eroded fins, lesions, and tumors occurred in fish communities downstream from dischargers of industrial and municipal wastewater and areas subjected to intermittent stresses from combined sewers and urban runoff. Leonard and Orth (1986) found that this metric corresponded to increased degradation in streams in West Virginia. Karr et al. (1986) observed that this metric was most sensitive in low quality streams.

The presence of the parasite black spot is not included in the DELT metric because infestation varied in degree and was a function of the presence of snails, an intermediate host. Thus, it was not solely related to environmental degradation (Allison et al. 1977; Berra and Au 1981). Whittier et al. (1987) and Steedman (1988) showed no relationship between stream quality and black spot infestation. Other parasites were also excluded due to the lack of a consistent relationship with environmental degradation.

Ohio EPA (1987) modified scores when individuals numbered less than 200, and DELT fish numbered over two fish. No scoring modifications were necessary for sites in the Lake Agassiz Plain since fish with DELT anomalies were uncommon and low numbers of species did not affect the performance of this metric (see low score modifications). This metric may be more important in the future as industrial development in the basin becomes more widespread. The proportion of individuals with DELT anomalies was not correlated with DA.

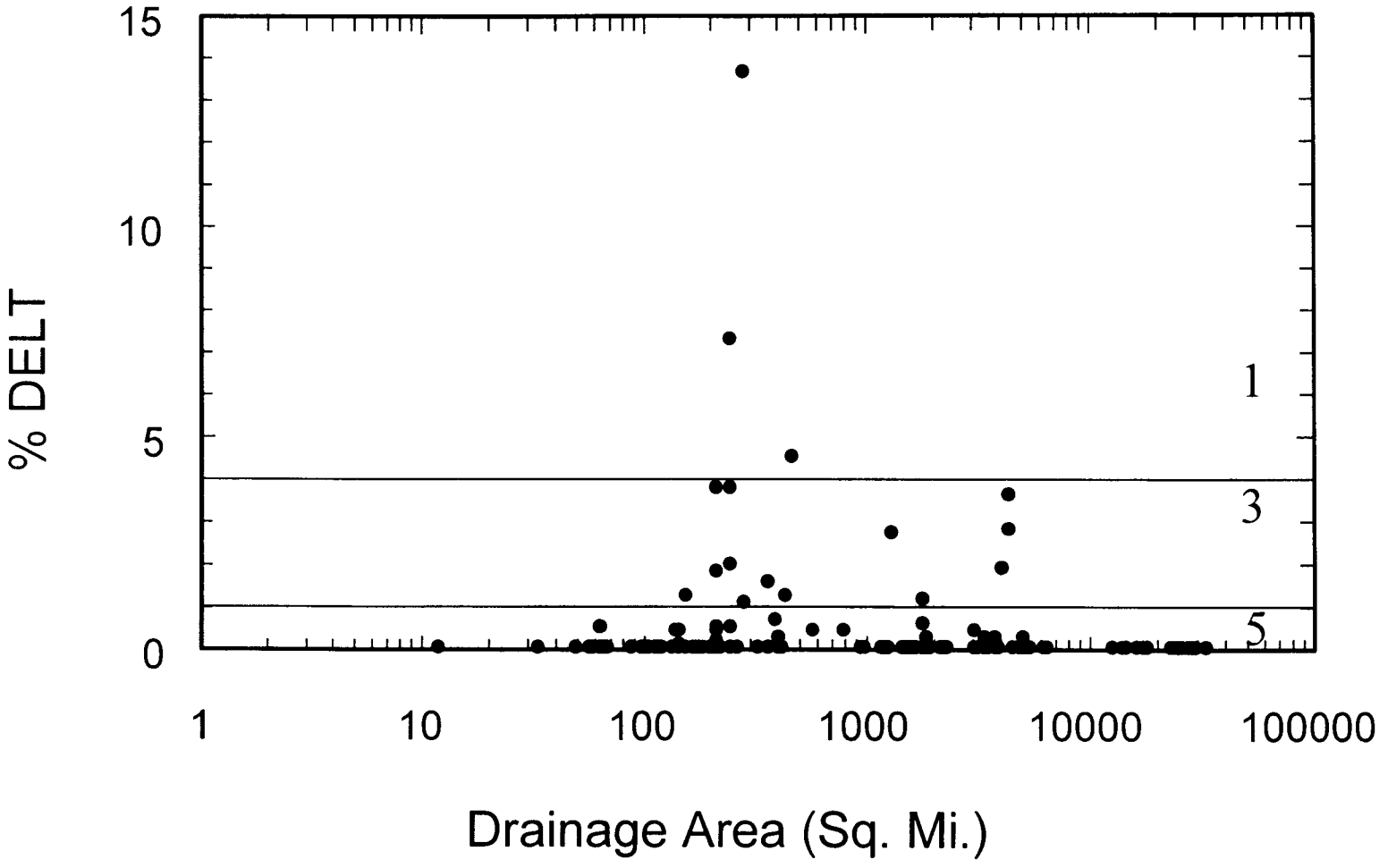

Figure 19: Maximum scoring lines for determining trends in the proportion of individuals with disease, eroded fins, lesions, and tumors (DELT) with increasing drainage area for the Lake Agassiz Plain ecoregion.

Alternative Metrics. Proportion of Subterminal-Mouth Minnows (Moderate Sized Streams) Number of Sucker Species (Moderate Sized Streams and Large Rivers)

Impetus

Four alternative metrics were considered for inclusion into the Lake Agassiz Plain IBI, but were not included in the scoring. The alternative metrics were used at the discretion of the researcher in situations where the final IBI score was close to the integrity classification cuttoffs or where a particular metric did not seem to be performing well.

The proportion of headwater individuals metric and the proportion of pioneer individuals metric were applicable in moderate sized streams as well as headwater streams (Tables 3 and 4; Fig. 5 and 15). The rationale for including these metrics in the Lake Agassiz Plain IBI was described earlier.

The proportion of subterminal-mouth minnows and the number of sucker species metrics were not included in the scoring for any stream size classification (Table 15 and 16; Fig. 20 and 21). Because subterminal mouth minnows and suckers were primarily benthic insectivores, they depended on the availability of interstitial habitat to provide food and cover. A high proportion of subterminal mouth minnows and sucker species were associated with high biotic integrity and a lack of siltation.

Table 15. Subterminal-mouth minnow species in the Lake Agassiz Plain ecoregion.

Common name	Scientific name
Central stoneroller	Campostoma anomalum
Largescale stoneroller	C. oligolepis
Longnose dace	R. cataractae
Silver chub	Macrhybopsis storeriana
Bluntnose minnow	Pimephales notatus
Bigmouth shiner	Notropis dorsalis
River shiner	N. blennius
Sand shiner	N. stramineus

Table 16. Sucker species in the Lake Agassiz Plain ecoregion.

Common name	Scientific name
Quillback	Carpiodes cyprinus
White sucker	Catostomus commersoni
Northern hogsucker	Hypentelium nigricans
Bigmouth buffalo	Ictiobus cyprinellus
Silver redhorse	Moxostoma anisurum
Golden redhorse	M. erythrurum
Shorthead redhorse	M. macrolepidotum
Greater redhorse	M. valenciennesi

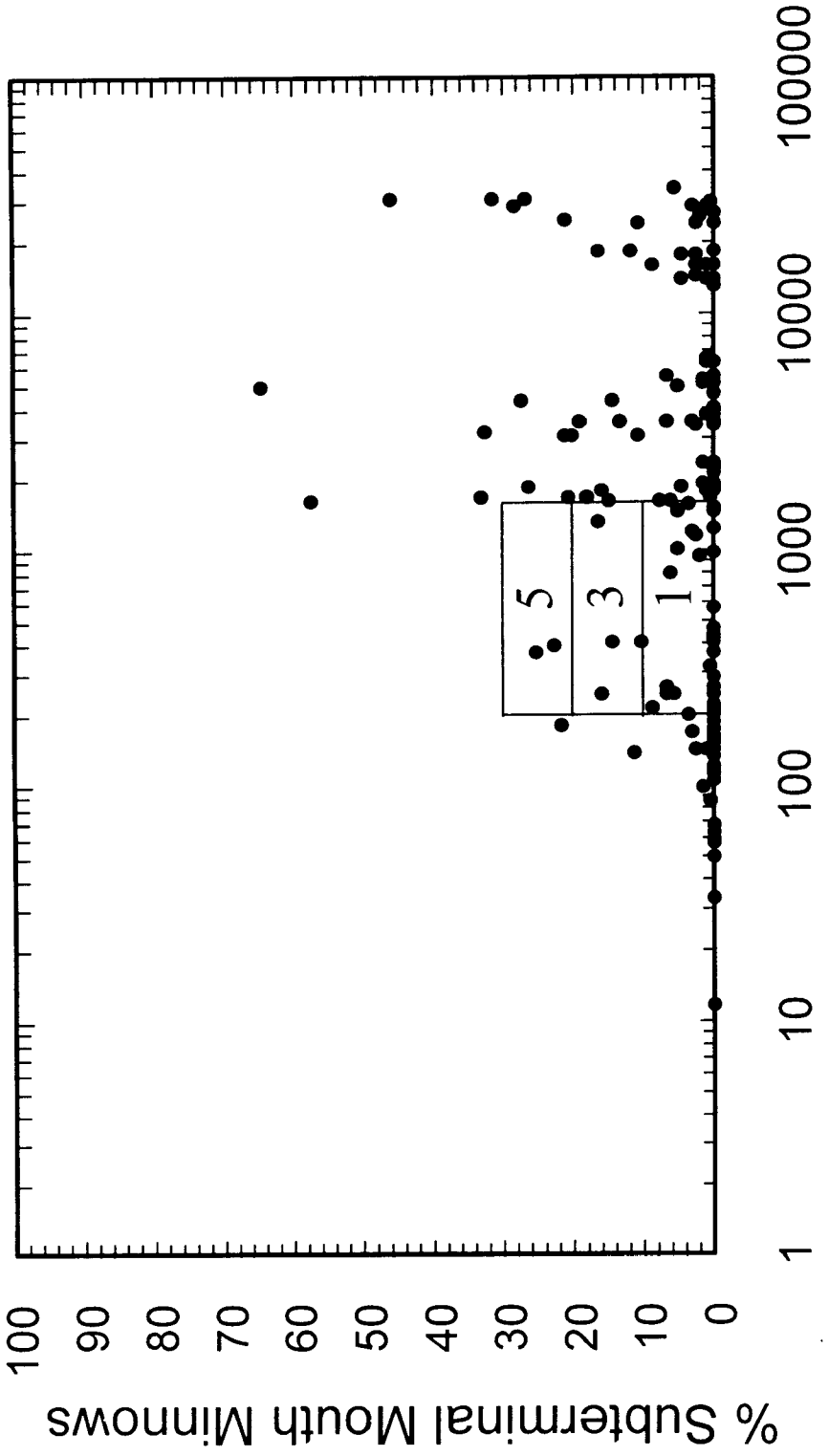

Figure 20: Maximum scoring lines for determining trends in proportion of subterminal mouth minnows with increasing drainage area for the Lake Agassiz Plain ecoregion.

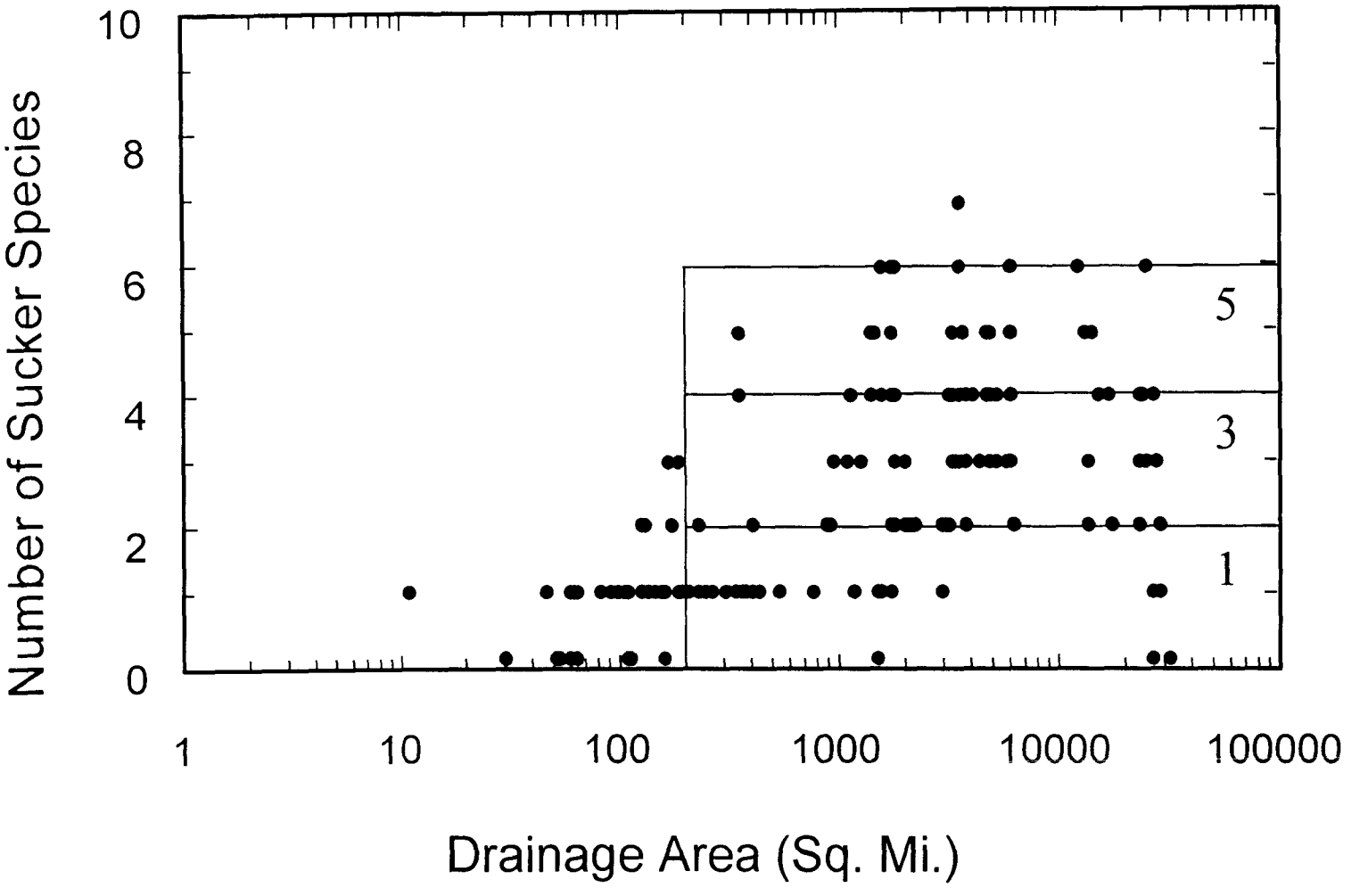

Figure 21: Maximum scoring lines for determining trends in number of sucker species with increasing drainage area for the Lake Agassiz Plain ecoregion.

Scoring Modifications

Samples with only a few species or extremely low numbers in the catch presented a scoring problem for some of the proportional metrics. Scoring adjustments were made to reduce the possibility of giving high scores to degraded sites. Aquatic habitats impacted by anthropogenic disturbances exhibited a disruption in the food base and the sample consisted of very few species or numbers of individuals. At such low population levels the normal structure of the community was unpredictable (Ohio EPA 1987). Ohio EPA (1987) observed that the proportion of omnivores, insectivorous fishes, and percent individuals affected by anomalies did not always match expected trends when fewer than 100 individuals were collected. Although scores were expected to deviate strongly from those of high quality areas, this was not always observed.

Similar to Ohio EPA (1987), Bailey et al. (1993) found that in the Minnesota River Basin many of the proportional metrics were unpredictable when the number of species at a site were extremely low. At these sites some of the proportional metrics did not reflect the quality of the resource because percent composition was unpredictably influenced by the presence of a few species. Low score modifications were necessary for the proportional metrics when the "number of species" metric scored a "1" indicating severe impairment.

Unlike Ohio however, the percentage of DELT anomalies metric was not modified in the Minnesota River basin because very few sites had species that exhibited these anomalies. This is probably because most sites were not directly impacted by industrial pollutants. Rather, habitat destruction through channelization and sedimentation were the primary anthropogenic influences on stream quality. Similar to the Minnesota River basin, few DELT anomalies were found in fish from the Lake Agassiz Plain ecoregion.

The following scoring modifications, based on information from Bailey et al. (1993) and Ohio EPA (1987), were adopted for evaluating sites in the Lake Agassiz Plain ecoregion. Modifications were applied where scoring became unpredictable due to a low number of individuals or species.

Headwater streams: Proportion of omnivore insectivore, simple lithophil, and pioneer species metrics should be scored a "1" if < 25 individuals were collected at a site or the number of species metric is scored a "1".

Moderate sized streams and Large Rivers: The proportion of piscivore, omnivore, insectivore, and simple lithophil metrics should be scored a "1" if < 50 individuals were collected at a site or when the number of species metric is scored a "1".

No scoring adjustments were necessary for proportion of tolerant species or the percent DELT anomalies. Further evaluation is needed to determine if scoring modifications is necessary for the other proportional metrics. In all cases, the biologist's best professional judgement should be used to decide when low-score modifications are appropriate.

4.0 RESULTS AND DISCUSSION

Lake Agassiz Plain

Species Composition: One hundred and eleven sites were sampled in the Lake Agassiz Plain during 1993 and 1994 (Fig. 3). Sixty three species were collected in 16 families (appendix A). This represents about 73% of the 86 species reported (Koel and Peterka 1994) to occur in the Red River basin. Numerically, cyprinids dominated the catch (74%) followed by catostomids (9%). The most abundant species were fathead minnow Pimephales promelas (20%), common shiner Luxilus cornutus (17%), and creek chub Semotilus atromaculatus (11%).

Cyprinids also dominated the catch in terms of biomass (40%). However, the common carp Cyprinus carpio made up 64% of the cyprinid biomass. If we exclude the common carp from the catch, catostomids were the dominate family by weight (35%) followed by cyprinids (14%). The dominant species by weight was the common carp (25%) followed by white sucker Catostomus commersoni (9%), and channel catfish Ictalurus punctatus (8%).

Three species: the rainbow trout Oncorhynchus mykiss, brook trout Salvalinus fontinalis, and white bass Morone chrysops were stocked for sport fisheries. The common carp was the only non-gamefish introduction collected during the study.

Trends in IBI Scoring: The IBI scores were highly variable throughout the Lake Agassiz Plain. There was virtually no correlation between IBI scores and DA (r^2=0.0838) (Fig. 22). IBI scores ranged from 16 to 48 or from very poor to good using Karr's integrity classification system modified for the Lake

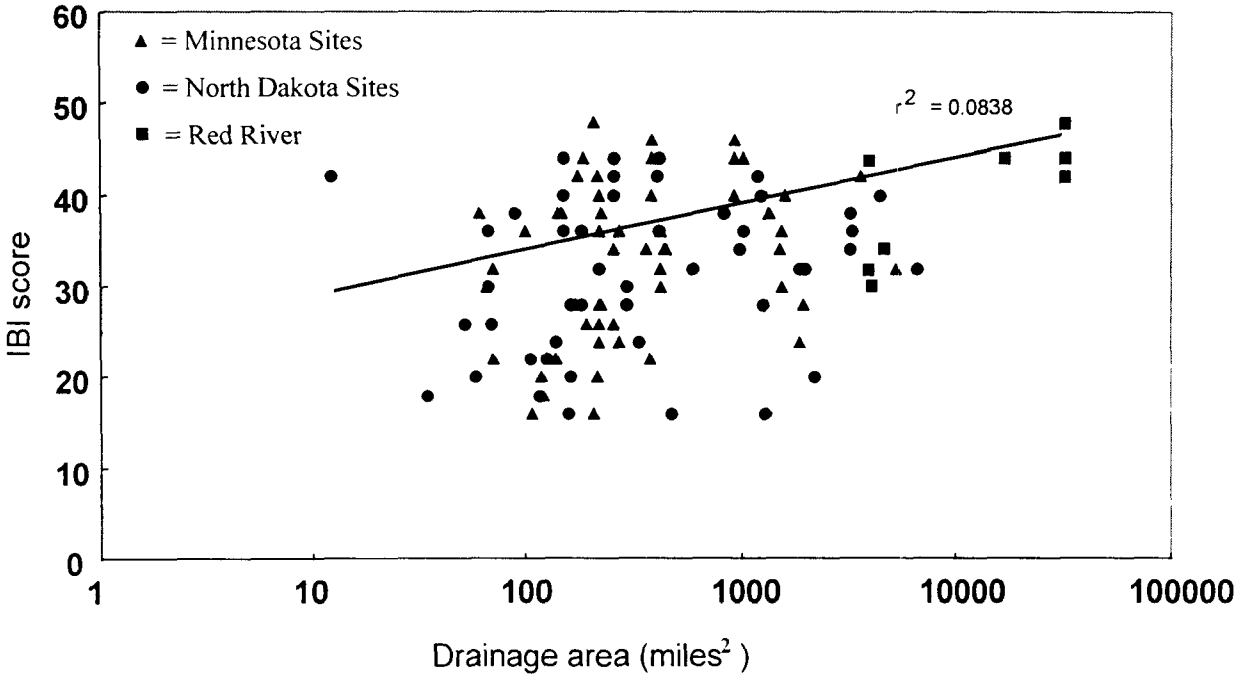

Figure 22: Plot of drainage area vs. IBI score for all sites sampled during the study period, 1993-1994. triangle markers represent sites sampled in Minnesota., circle markers for North Dakota, and square markers for sites sampled on the Red River.

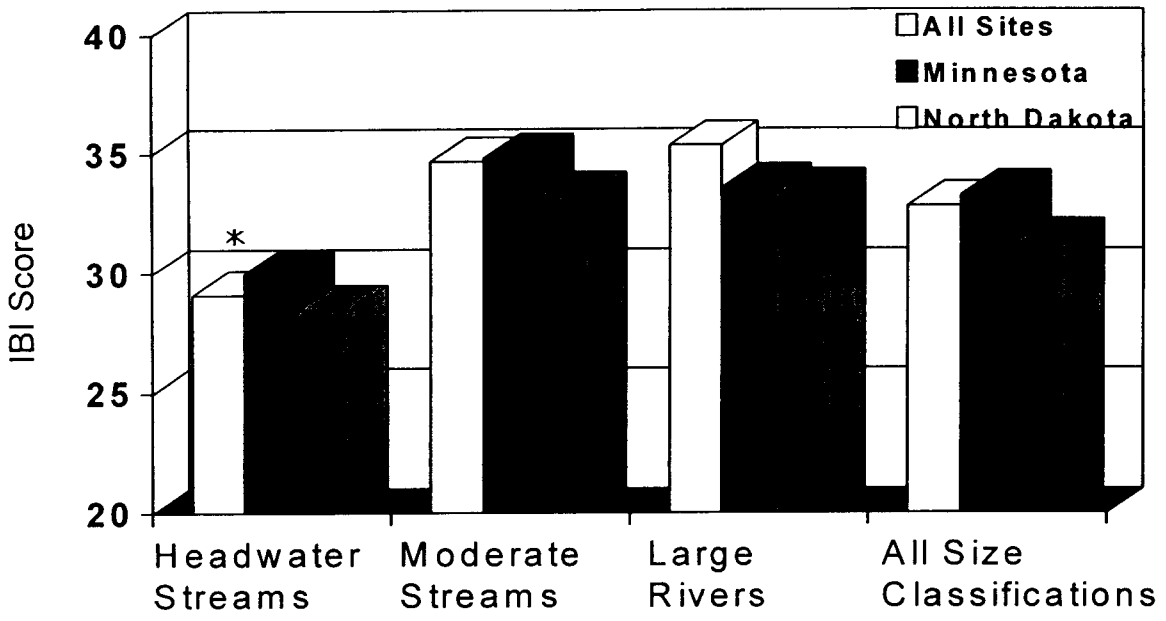

Figure 23: Mean IBI scores for headwater, moderate, large rivers and all size streams. Scores for Minnesota and North Dakota excluded the Red River sites while the scores for all sites included the Red River sites. Asterisks indicated a significant difference from other stream sizes (ANOVA, $P < 0.05$).

Agassiz Plain ecoregion (Table 1). The average overall score was 32 (Fig. 23). Forty percent of all sites were rated fair (Fig. 24). There were no excellent sites (>50) in the ecoregion (Fig. 24).

Although we attempted to find the highest quality sites for the purpose of establishing reference conditions, the sites selected for this study should not be considered pristine. The sites that we selected represented the best conditions present in the basin but most likely did not reflect historical environmental conditions for this ecoregion. The rivers and streams in the Lake Agassiz Plain ecoregion were modified extensively through channel modification, etc. With improved land and water management practices we expect some sites to move into the excellent category (>50).

Metric score averages provided insight into fish community condition in the ecoregion. For instance, the average metric score for the percentage of DELT anomalies was very high (4.56) indicating that pollution sources within the ecoregion were not affecting fish health. Increases in the prevalence of DELT anomalies have been found in degraded stream habitats, often associated with industrial and municipal discharges (Simon 1992). Since we attempted to avoid these areas we did not expect to see significant numbers of DELT anomalies. The proportion of omnivore biomass score averaged 3.30 and the proportion of insectivore biomass averaged 2.98. These scores were high relative to the other metric scores. This indicates that streams within the ecoregion generally had a stable food base that allowed the more specialized feeders to thrive. The proportion of simple lithophilic spawners scored the lowest of all metrics. Siltation was the most likely limiting factor affecting those species that relied on clean gravel and cobble substrates to successfully reproduce.

Headwater, Moderate, and Large Rivers

Species Composition: Community composition varied among headwater streams, moderate sized streams, and large rivers. Sampling at headwater streams (<200 mi^2 DA) found 33 species in 9 families. The most abundant species in headwater streams were fathead minnows (41%), blacknose dace Rhinichthys atratulus (12%), and brook stickleback Culaea inconstans (11%). Forty seven species in 14 families were found in moderate sized streams (200-1500 mi^2 DA). The most abundant species in moderate sized streams were common shiners (23%), creek chubs (13%), and fathead minnows (13%). Sampling in large rivers (>1500 mi^2 DA) found 55 species in 14 families. The dominant species in large rivers were fathead minnows (16%), common shiners (14%), and spotfin shiners Cyprinella spiloptera (11%).

Trends in IBI Scoring: The average IBI score for headwater streams was 29.1, which was significantly lower (ANOVA, $p < .05$) than either moderate streams (mean=34.1) or large rivers (mean=35.3) (Fig. 23). Fifty five percent of all headwater streams were rated poor or very poor. This contrasted with the better rating of moderate sized streams and large rivers. Only 28% of moderate sized streams were rated poor or very poor and only 12% of large rivers were rated as such (Fig. 24).

There were a number of plausible explanations for the low biotic integrity of headwater streams in the Lake Agassiz Plain ecoregion. Stream channelization, particularily prevalent in headwater stream reaches, had undoubtedly led to some impairments to resource quality. Its negative effects were most pronounced on small headwater streams where many have been straightened and rerouted to serve as field drainage systems for row crops. Stream channelization reduced habitat quality by reducing pool depth and substrate heterogeneity,

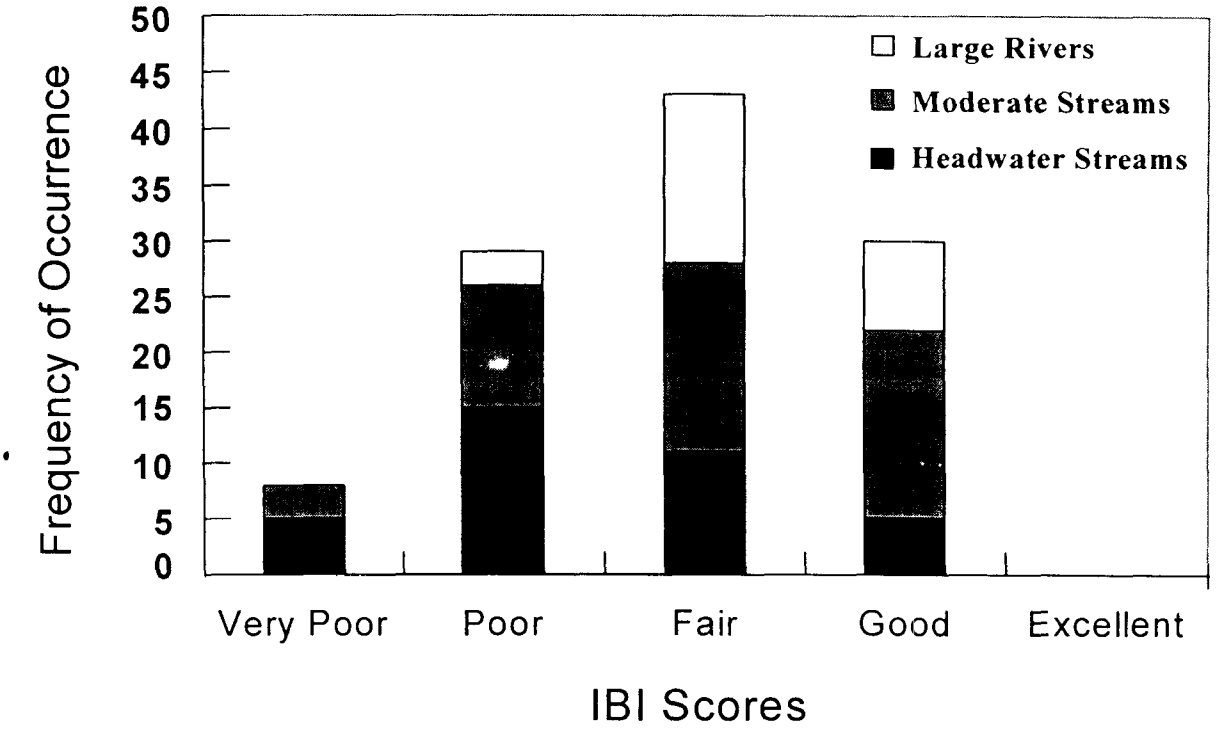

Figure 24: Integrity ranking for all sites sampled during the 1993-1994 study period based on the modified integrity classification developed for the Lake Agassiz Plain ecoregion of Minnesota and North Dakota..

altering riffle-run-pool sequences, increasing turbidity, and reducing the retention time for water remaining in the stream channel (Rankin et al. 1992).

Due to the degree of channelization in this ecoregion, it was impossible to totally avoid the negative influence of channelization on habitat quality. Many headwater sites, although not channelized, were often surrounded upstream and downstream by large segments of channelized stream. These unaltered stream segments, while certainly not pristine, represented the best conditions found in many of these streams and provided an important habitat refuge for biota.

In addition to channel modification, headwater sites often underwent extreme fluctuations in flow and created temporal changes in habitat availability for fish. Low flow conditions at headwater sites benefited pioneer spieces by forcing fish to move out of an area for a period of time and then recolonize the area later when conditions improved. Conversely, high flow conditions also created unstable environments due primarily to increased velocity and turbidity. These conditions were exacerbated by channelization that was so prevalent in the Lake Agassiz Plain ecoregion. As expected, a relatively large proportion (39%) of the total number of species collected in headwater environments were pioneer species. These species were opportunists that were able to take advantage of temporarily available habitat.

The importance of headwater streams cannot be over emphasized. Although headwater streams in this ecoregion did not typically support year-round game fish populations, they did serve an important function in providing many game fish species with suitable spawning habitat. In addition, headwater streams were important components in river drainage networks and served as an entry point for pollutants from the terrestial environment (Bailey et al. 1993). Therefore, the condition of moderate sized streams and large rivers was intimately tied to the condition of headwater streams.

Minnesota and North Dakota

Species Composition: In general, streams in the eastern portion of the basin had a higher species richness than those in the west. Excluding the border waters of the Red River, 52 species were collected in Minnesota streams while 46 species were collected in North Dakota.

Some of the rivers in the basin, like the Otter Tail River of Minnesota, were known to have a high species diversity (Koel and Peterka 1994). We collected 23 species from one site on the Otter Tail River that included 4 species not collected in any other river during the study: green sunfish Lepomis cyanellus, largemouth bass Micropterus salmoides, greater redhorse Moxostoma valenciennesi, and logperch Percina caprodes. The Otter Tail was like many of the other tributaries to the Red River in Minnesota in that it flowed through a number of ecoregions. Originating in the Northern Lakes and Forests ecoregion, the Ottertail flowed southward into the Central Hardwood Forests ecoregion before turning west into the Lake Agassiz Plain. The rolling hills and abundance of lakes and wetlands in the upper two ecoregions contrasted sharply with the relatively featureless topography of the Lake Agassiz Plain ecoregion. This diversity of habitat, while common to tributaries in the eastern portion of the basin, was not present in the western side of the basin.

A number of species were unique to one state, either Minnesota or North Dakota. Species collected only in Minnesota included mooneye Hiodon tergisus, goldeye Hiodon alosoides, bigmouth buffalo Ictiobus cyprinellus, silver lamprey Ichthyomyzon unicuspis, green sunfish, pumpkinseed Lepomis gibbosus, burbot Lota lota, largemouth bass, greater redhorse, blacknose shiner Notropis heterolepis, logperch, finescale dace Phoxinus neogeaus, sauger Stizostedion canadense, and central mudminnow Umbra limi. Eight of these species were collected from either the Otter Tail or Wild Rice Rivers of Minnesota. The central mudminnow was found extensively throughout the Minnesota portion of the basin (33 sites) but was not collected from North Dakota during the study. Eight species were collected only in North Dakota: largescale

stoneroller Campostoma oligolepis, banded killifish Fundulus diaphanus, brown bullhead Ameiurus nebulosus, brassy minnow Hybognathus hankinsoni, bluegill Lepomis macrochirus, orangespotted sunfish Lepomis humilis, golden shiner Notemigonus crysoleucas, and rainbow trout. Six of the 8 species collected exclusively from North Dakota were from either the Turtle or Sheyenne Rivers.

Trends in IBI Scoring: IBI scores were slightly higher for streams in Minnesota compared to those in North Dakota (Fig. 23). Although significant differences in IBI scoring were not found between the states, there were some differences in individual metrics. For instance, the species richness metric scored higher at Minnesota streams for all stream size classifications. These differences in species richness were expected for reasons given earlier. Somewhat more perplexing is that most of the biomass metrics and the catch-per-unit effort metric scored higher in North Dakota than Minnesota. Only insectivore biomass in headwater streams was higher in Minnesota. The higher catch rates in North Dakota suggested that these streams may be more productive.

Pioneer species occurred much more frequently in North Dakota headwater streams. With the exception of the green sunfish, every pioneer species was more common in North Dakota. The likely explanation for this may lie in the temporary nature of headwater streams in North Dakota that was related to climatic and topographical factors. Headwater streams in North Dakota typically originated in relatively dry prairie environments. Because of this, periods of drought may have caused rapid and prolonged decreases in stream flow making some sections of the stream uninhabitable to fish. In contrast, Minnesota headwater streams were linked with wetland habitat that had the effect of modifying these hydrologic extremes. In addition, the Minnesota portion of the Red River basin received more annual precipitation than North Dakota.

Sensitive species were much more common in Minnesota. The average IBI score for this metric in Minnesota streams was 2.51. This is almost a full point higher than the average IBI score of for streams in North Dakota. There were 7 sensitive species collected in Minnesota that were not found in North Dakota. These species included the goldeye, mooneye, greater redhorse, blacknose shiner, log perch, trout perch Percopsis omiscomaycus, and finescale dace. Sensitive species such as the northern hogsucker Hypentelium nigricans, rainbow darter Etheostoma caeruleum, pugnose Notropis anogenus, mimic Notropis volucellus, and blackchin shiners Notropis heterodon were known to historically occur in the ecoregion, but were not collected in either state during the study period.

The Red River

Species Composition: The Red River was sampled at 8 locations from sites close to its source to sites near the Canadian border (Fig. 25). Thirty six species in 12 families were collected from the Red River. Spotfin shiner (38%), emerald shiner Notropis atherinoides (33%), and silver chubs Macrhybopsis storeriana (4%) were the most abundant species. Shorthead redhorse Moxostoma macrolepidotum (20%), silver redhorse Moxostoma anisurum (16%), and common carp (15%) dominated the catch in terms of biomass. Three species: the white bass, silver chub, and river shiner Notropis blennius were unique to the Red River. This survey compared favorably with the 1983-1984 Red River survey by Renard et al. (1986). Renard et al. (1986) sampled 40 stations and collected the same number of species (36). This indicated that the 8 sites sampled in this study were sufficient to characterize the fish community of the Red River.

Trends in IBI Scoring: Sites surveyed in the Red River ranged from fair (score of 32) to good (score of 48) based on IBI scoring criteria (Fig. 25). IBI scores were generally higher in the Red River compared to other large rivers in the ecoregion. The mean IBI score for the Red River was 39.5 while other large river sites averaged 33.4. Metrics that scored particularly well in the Red River included the number of large river species, proportion of omnivore species, and proportion of tolerant individuals. The tolerant species metric attained a maximum score of 5 at every site sampled. The number of simple lithophilic individuals and

proportion of round-bodied suckers metrics scored poorly in the Red River (mean scores of both were 1.5). This suggested that many fish species were doing quite well in the Red River but siltation may be limiting those fish species that required clean gravel substrates to successfully reproduce.

The 8 sites located on the Red River were widely dispersed and provided insight into the biotic integrity of this river along a longitudinal gradient (Fig. 25). In spite of the input from a multitude of potential pollution sources, IBI scores did not decrease with increasing distance downstream. Rather, some of the highest scoring sites were located nearest the Canadian border.

The evenness and the CPUE metrics scored particularily well at the downstream sites indicating an abundant, well-balanced fish population that was not dominated by opportunistic or tolerant species. However, simple lithophils and round-bodied sucker species metrics continued to score poorly at the downstream sites.

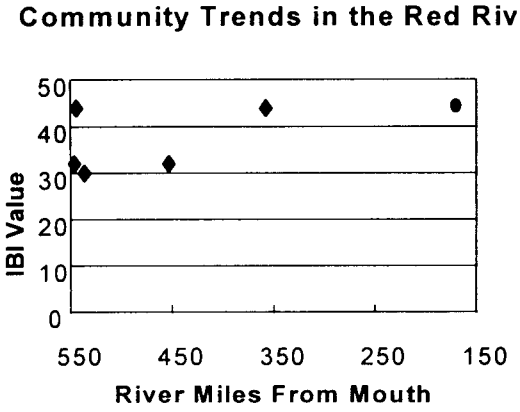

Figure 25: Longitudinal community trends in IBI scores for the Red River. The circle marker (river mile 173) is an average.

Variability

Although variability throughout the Lake Agassiz Plain was quite evident, variability in sampling technique between agencies needed to be eliminated as a source Two types of variability were examined to determine if any bias in sampling occurred.

Temporal variability was measured at eight sites. These sites were sampled during different years (1993-1994) and sampled the same year during different time periods. Sampling procedures remained the same between time periods; however, many of the sites were repeated with different crews. Differences between years were not significantly different (ANOVA, $p>0.05$). Differences for sites repeated during the same year were also not significantly different (ANOVA, $p>0.05$). Coefficient of variation (CV), was used to compare the relative amounts of variation at each site. Mean CV for all eight sites and all 20 samples was 9.06 percent.

Five sites, each with three consecutive reaches, were sampled on the same day by a single crew to examine the adaquacy of the reach length. The mean CV for these sites was 7.3 percent. Less than two percent difference existed between temporal variability with multiple samplers and the reach variability.

This data suggested that reach lengths were sufficient to characterize the fish community and that bias among samplers, sampling time or sampling equipment was not significant.

Reference Sites

A list of reference sites was developed from data collected during 1993-1994 for the Lake Agassiz Plain ecoregion (Table 17). Inclusion of a site into this list was based on superior IBI scores, habitat characteristics, and professional judgement. Since these sites were thought to represent the reference condition, future monitoring efforts should concentrate on these sites to recalibrate the metrics and further refine the reference site list. Hughes (1995) suggested that the reference condition should be set as high as possible to adequately protect the resource. Since the reference condition in the Lake Agassiz Plain represented a considerable amount of disturbance, only sites with IBI scores in the 90th percentile were considered reference sites.

As mentioned earlier, these sites should not be considered pristine but may well be described as the "least impacted" sites for the Lake Agassiz Plain. It

was also important to consider that reference conditions do not remain static. On the contrary, repeat monitoring and sampling of stations, both reference and site specific, will be needed in order to add to and refine the list of reference sites, document change over time, and further refine the IBI for the Lake Agassiz Plain ecoregion.

Table 17: Reference sites determined using fish community biotic integrity for the Lake Agassiz Plain ecoregion, Minnesota, North Dakota, and the Red River.

Minnesota	**South Branch Wild Rice River**: E of CSAH 27 bridge, T 142 R 45 S 16. Long: 96° 24' 08" Lat: 47° 07' 01" (site: 94-012)
	South Branch Wild Rice River: W of CR 136 bridge, T 143 R 46 S 30. Long: 96° 33' 35" Lat: 47° 10' 15" (site: 94-013)
	Buffalo River: USGS site near Buffalo River State Park, Field # 46514909, T 139 R 46 S 11. Long: 96° 28' 04" Lat: 46° 51'49" (site: 94-507)
	Buffalo River: At CR 26, 2.5 mi E of Kragnes, T 141 R 48 S 36. Long: 96° 41' 26" Lat: 46° 58' 39" (site: 94-019)
	Marsh River: North of CR 129 bridge, T 146 R 48 S 34. Long 96° 45' 58" Lat: 47° 24' 44" (site: 94-014)
North Dakota	**North Branch Turtle River**: SH 18 bridge, 3 mi N of Hwy 2 Junct. Long: 97° 37' 25" Lat: 47° 59' 31" (site:94-125)
	Turtle River: At State Park. Long: 97° 30' 00" Lat: 47° 56' 18". (site: 94-502, 94-523 94-524)
	Forest River: 2 mi N Inkster. Long: 97° 38' 37" Lat: 48° 10' 46". (site: 94-130)
	Goose River: USGS site at Hillsboro, Field # 0506650. Long: 97° 03' 39" Lat: 47° 24' 34" (site: 94-504)
	Pembina River: USGS site at Walhalla, Field # 05099600. Long: 97° 55' 00" Lat: 48° 54' 50" (site: 94-505)
Red River	**Red River**: East of Joliette. Long: 97° 10' 43" Lat: 48° 48' 51". (site: 94-528, 94-529, 94-530)
	Red River: 0.5 mi W of Hwy 75, T 133 R 47 S 21. Long: 96° 36' 03" Lat: 46° 19' 36" (site: 94-021)
	Red River: 0.5 mi W of end of CR 109, T 144 R 48 S 1. Long: 96° 49' 45" Lat: 47° 19' 35" (site: 94-018)

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6.0 APPENDICES

A. Current and historical fish species found in the Red River Basin (native, exotic, stocked) and those species collected from the Lake Agassiz Plain ecoregion during the 1993-1994 study period..

B. Site specific IBI scores for the stations sampled in the Lake Agassiz Plain ecoregion.

Lake Agassiz Plain

Appendix A. Current and historic fish species found in the Red River Basin (native, exotic, stocked) and those species collected from the Lake Agassiz Plain ecoregion. (An X indicates species found during the 1993-1994 ecoregion study). This species list provided by Todd Koel, Ph.D. candidate, North Dakota State University.

FAMILY SPECIES	COMMON NAME	MINNESOTA	NORTH DAKOTA	RED RIVER
Acipenseridae - Sturgeon				
Acipenser fulvescens	lake sturgeon			
Amiidae - Bowfin				
Amia calva	bowfin			
Cottidae - Sculpins				
Cottus bairdi	mottled sculpin			
Catostomidae - Suckers				
Carpiodes carpio	river carpsucker			
Carpiodes cyprinus	quillback	X	X	X
Catostomus commersoni	white sucker	X	X	X
Hypentelium nigricans	northern hog sucker			
Ictiobus cyprinellus	bigmouth buffalo	X	X	X
Moxostoma anisurum	silver redhorse	X	X	X
Moxostoma erythrurum	golden redhorse	X	X	X
Moxostoma macrolepidotum	shorthead redhorse	X	X	X
Moxostoma valenciennesi	greater redhorse	X		
Centrarchidae - Sunfishes				
Ambloplites rupestris	rock bass	X	X	X
Lepomis cyanellus	green sunfish	X		
Lepomis gibbosus	pumpkinseed	X		
Lepomis humilis	orangespotted sunfish		X	
Lepomis macrochirus	bluegill		X	X
Micropterus dolomieu	smallmouth bass	X	X	

FAMILY SPECIES	COMMON NAME	MINNESOTA	NORTH DAKOTA	RED RIVER
Micropterus salmoides	largemouth bass	X		
Pomoxis annularis	white crappie			
Pomoxis nigromaculatus	black crappie	X	X	X
Cyprinidae - Minnows				
Campostoma anomalum	central stoneroller			
Campostoma oligolepis	largescale stoneroller		X	
Cyprinella spiloptera	spotfin shiner	X	X	X
Cyprinus carpio	common carp	X	X	X
Hybognathus hankinsoni	brassy minnow		X	
Luxilus cornutus	common shiner	X	X	X
Macrhybopsis storeriana	silver chub			X
Margariscus margarita	pearl dace	X	X	
Nocomis biguttatus	hornyhead chub	X	X	X
Notemigonus crysoleucas	golden shiner			
Notropis anogenus	pugnose shiner			
Notropis atherinoides	emerald shiner	X	X	X
Notropis blennius	river shiner			X
Notropis dorsalis	bigmouth shiner	X	X	
Notropis heterodon	blackchin shiner			
Notropis heterolepis	blacknose shiner	X		
Notropis hudsonius	spottail shiner	X	X	X
Notropis rubellus	rosyface shiner	X	X	
Notropis stramineus	sand shiner	X	X	X
Notropis texanus	weed shiner			
Notropis volucellus	mimic shiner			
Phoxinus eos	northern redbelly dace	X	X	
Phoxinus neogaeus	finescale dace	X		

Lake Agassiz Plain

FAMILY SPECIES	COMMON NAME	MINNESOTA	NORTH DAKOTA	RED RIVER
Pimephales notatus	bluntnose minnow	X	X	
Pimephales promelas	fathead minnow	X	X	X
Platygobio gracilus	flathead chub			
Rhinichthys atratulus	blacknose dace	X	X	
Rhinichthys cataractae	longnose dace	X	X	
Semotilus atromaculatus	creek chub	X	X	X
Cyprinodontidae - Killifishes				
Fundulus diaphanus	banded killifish		X	
Esocidae - Pikes				
Esox lucius	northern pike	X	X	X
Esox masquinongy	muskellunge			
Gadidae - Codfishes				
Lota lota	burbot	X		X
Gasterosteidae - Sticklebacks				
Culaea inconstans	brook stickleback	X	X	
Hiodontidae - Mooneyes				
Hiodon alosoides	goldeye	X		X
Hiodon tergisus	mooneye	X		X
Ictaluridae - Bullhead Catfishes				
Ameiurus melas	black bullhead	X	X	X
Ameiurus natalis	yellow bullhead			
Ameiurus nebulosus	brown bullhead		X	
Ictalurus punctatus	channel catfish	X	X	X
Noturus flavus	stonecat	X	X	X
Noturus gyrinus	tadpole madtom	X	X	

FAMILY SPECIES	COMMON NAME	MINNESOTA	NORTH DAKOTA	RED RIVER
Lepisosteidae - Gars				
Lepisosteus osseus	longnose gar			
Percichthyidae - Temperate Basses				
Morone chrysops	white bass			X
Percidae - Perches				
Etheostoma caeruleum	rainbow darter			
Etheostoma exile	iowa darter	X	X	
Etheostoma microperca	least darter			
Etheostoma nigrum	johnny darter	X	X	X
Perca flavescens	yellow perch	X	X	X
Percina caprodes	logperch	X		
Percina maculata	blackside darter	X	X	X
Percina shumardi	river darter			
Stizostedion canadense	sauger	X		X
Stizostedion vitreum	walleye	X	X	X
Percopsidae - Trout-perch				
Percopsis omiscomaycus	trout-perch	X	X	X
Petromyzontidae - Lamprey				
Ichthyomyzon castaneus	chestnut lamprey	X	X	
Ichthyomyzon unicuspis	silver lamprey	X		X
Salmonidae - Trouts				
Coregonus artedi	ciscoe			
Coregonus clupeaformis	lake whitefish			
Oncorhynchus mykiss	rainbow trout		X	
Salmo trutta	brown trout			

FAMILY SPECIES	COMMON NAME	MINNESOTA	NORTH DAKOTA	RED RIVER
Salvelinus fontinalis	brook trout			
Sciaenidae - Drums				
Aplodinotus grunniens	freshwater drum	X	X	X
Umbridae - Mudminnows				
Umbra limi	central mudminnow	X		
Total Number of Species	**85**	**52**	**46**	**36**

Appendix B: Site specific Index of Biotic Integrity scores for each of the stations sampled in the Lake Agassiz Plain ecoregion. Stations are sorted by state and field number. Total IBI scores with an asterisk have been low score modified (see page 47 for an explanation of low score modifications)

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-400 Drainage Area: 70 mi^2 Date: 7-20-1993

Site: MN: Kittson Co: Joe River at CR 16/intersection, 4 mi ENE St. Vincent, T 139 R 50 S 34.
Long: 97° 07'47" Lat: 48° 59'30"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	3	1
2. PROPORTION OF HEADWATER SPECIES	48.6%	3
3. EVENNESS	0.907	5
4. NUMBER OF MINNOW SPECIES	1	1
5. PROPORTION OF OMNIVORE BIOMASS	7.8%	1
6. PROPORTION OF INSECTIVORE BIOMASS	92.2%	1
7. PROPORTION OF SIMPLE LITHOPHILS	0.0%	1
8. PROPORTION OF TOLERANT SPECIES	51.4%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	37.1%	1
11. NUMBER OF INDIVIDUALS/METER	0.35	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		22*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-401 Drainage Area: 438 mi^2 Date: 7-20-1993

Site: MN: Kittson Co: South Branch Two Rivers at Albin bridge, 3 mi SE of Hallock, T161 R 48 S 32.
Long: 96° 53' 44" Lat: 48° 43' 54"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	11	3
2. NUMBER OF BENTHIC INSECTIVORES	3	1
3. EVENNESS	0.793	3
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF PISCIVORE BIOMASS	18.1%	3
6. PROPORTION OF OMNIVORE BIOMASS	14.0%	5
7. PROPORTION OF INSECTIVORE BIOMASS	67.9%	5
8. PROPORTION OF SIMPLE LITHOPHILS	36.5%	3
9. PROPORTION OF TOLERANT SPECIES	67.1%	1
10. NUMBER OF SENSITIVE SPECIES	1	1
11. NUMBER OF INDIVIDUALS/METER	2.05	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		34

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-403 Drainage Area: 224 mi^2 Date: 7-20-1993

Site: MN: Kittson Co: North Branch Two Rivers at SR 6 bridge, Lancaster, T 162 R 48 S 13.
Long: 96° 49' 03" Lat: 48° 51' 34"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	6	3
2. NUMBER OF BENTHIC INSECTIVORES	0	1
3. EVENNESS	0.914	5
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	44.4%	3
7. PROPORTION OF INSECTIVORE BIOMASS	55.6%	3
8. PROPORTION OF SIMPLE LITHOPHILS	40.4%	3
9. PROPORTION OF TOLERANT SPECIES	78.9%	1
10. NUMBER OF SENSITIVE SPECIES	1	1
11. NUMBER OF INDIVIDUALS/METER	2.28	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		28

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-404 Drainage Area: 145 mi^2 Date: 7-20-1993

Site: MN: Kittson Co: North Branch Two Rivers at TR bridge, 2 mi NE of Lancaster, T 162 R 47 S 9.
Long: 96° 45' 16" Lat: 48° 52' 30"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	8	3
2. PROPORTION OF HEADWATER SPECIES	38.9%	3
3. EVENNESS	0.911	5
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF OMNIVORE BIOMASS	37.5%	3
6. PROPORTION OF INSECTIVORE BIOMASS	62.5%	5
7. PROPORTION OF SIMPLE LITHOPHILS	41.7%	3
8. PROPORTION OF TOLERANT SPECIES	56.3%	1
9. NUMBER OF SENSITIVE SPECIES	2	3
10. PROPORTION OF PIONEER SPECIES	27.1%	5
11. NUMBER OF INDIVIDUALS/METER	2.68	1
12. PERCENT DELT	0.4%	5
TOTAL IBI SCORE		38

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-405 Drainage Area: 118 mi^2 Date: 7-20-1993

Site: MN: Kittson Co: Middle Branch Two Rivers between TR 59 & 15, 3 mi N of Lake Bronson, T 161 R 47 S 1. Long: 96° 40'35" Lat: 48° 47' 21"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	3	1
2. PROPORTION OF HEADWATER SPECIES	69.9%	5
3. EVENNESS	0.585%	1
4. NUMBER OF MINNOW SPECIES	1	1
5. PROPORTION OF OMNIVORE BIOMASS	0.1%	1
6. PROPORTION OF INSECTIVORE BIOMASS	99.9%	1
7. PROPORTION OF SIMPLE LITHOPHILS	0.0%	1
8. PROPORTION OF TOLERANT SPECIES	30.1%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	0.6%	1
11. NUMBER OF INDIVIDUALS/METER	2.05	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		20*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-406 Drainage Area: 420 mi^2 Date: 7-20-1993

Site: MN: Kittson Co: South Branch Two Rivers at CR 15/HWY 59 bridge, Lake Bronson, T 161 R 46 S 31.
Long: 96° 40' 04" Lat: 48° 43' 54"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	12	3
2. NUMBER OF BENTHIC INSECTIVORES	3	1
3. EVENNESS	0.624	3
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF PISCIVORE BIOMASS	5.5%	1
6. PROPORTION OF OMNIVORE BIOMASS	39.4%	3
7. PROPORTION OF INSECTIVORE BIOMASS	55.2%	3
8. PROPORTION OF SIMPLE LITHOPHILS	67.1%	5
9. PROPORTION OF TOLERANT SPECIES	67.7%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	2.48	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		30

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-407 Drainage Area: 270 mi^2 Date: 7-20-1993

Site: MN: Kittson Co: South Branch Two Rivers at SR 11 bridge , 6 mi NE Karlstad, T 160 R 45 S 36.
Long: 96° 23' 12" Lat: 48° 38' 33"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	7	3
2. NUMBER OF BENTHIC INSECTIVORES	1	1
3. EVENNESS	0.763	3
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	52.3%	3
7. PROPORTION OF INSECTIVORE BIOMASS	47.7%	3
8. PROPORTION OF SIMPLE LITHOPHILS	21.6%	1
9. PROPORTION OF TOLERANT SPECIES	68.9%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	2.96	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		24

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-416 Drainage Area: 170 mi^2 Date:7-22-1993

Site: MN: Marshall Co: Snake River at 5th Street bridge, 0.125 mi NW of Warren, T 155 R 48 S 36.
Long: 96° 46' 02" Lat: 48° 12' 02"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	6	3
2. PROPORTION OF HEADWATER SPECIES	34.9%	3
3. EVENNESS	0.671	3
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF OMNIVORE BIOMASS	77.3%	1
6. PROPORTION OF INSECTIVORE BIOMASS	22.7%	1
7. PROPORTION OF SIMPLE LITHOPHILS	11.1%	1
8. PROPORTION OF TOLERANT SPECIES	65.1%	1
9. NUMBER OF SENSITIVE SPECIES	2	3
10. PROPORTION OF PIONEER SPECIES	57.1%	3
11. NUMBER OF INDIVIDUALS/METER	2.52	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		28

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-417 Drainage Area: 255 mi^2 Date: 7-22-1993

Site: MN: Marshall Co: Middle River at CR 4 bridge, 0.25 mi E of Argyle, T 156 R 48 S 15. Long: 96° 48' 40" Lat: 48° 20' 16"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	10	3
2. NUMBER OF BENTHIC INSECTIVORES	2	1
3. EVENNESS	0.671	3
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	99.2%	1
7. PROPORTION OF INSECTIVORE BIOMASS	0.8%	1
8. PROPORTION OF SIMPLE LITHOPHILS	31.7%	3
9. PROPORTION OF TOLERANT SPECIES	70.4%	1
10. NUMBER OF SENSITIVE SPECIES	1	1
11. NUMBER OF INDIVIDUALS/METER	4.80	3
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		26

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-418 Drainage Area: 205 mi^2 Date: 7-22-1993

Site: MN: Marshall Co: Tamarac River at TR 9 bridge, 9 mi SE of Stephan, T 157 R 47 S 14. Long: 96° 41' 31" Lat: 48° 24' 56"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	5	1
2. NUMBER OF BENTHIC INSECTIVORES	1	1
3. EVENNESS	0.406	1
4. NUMBER OF MINNOW SPECIES	0	1
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	15.0%	1
7. PROPORTION OF INSECTIVORE BIOMASS	85.0%	1
8. PROPORTION OF SIMPLE LITHOPHILS	2.3%	1
9. PROPORTION OF TOLERANT SPECIES	83.7%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	1.72	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		16*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-419 Drainage Area: 220 mi^2 Date: 7-22-1993

Site: MN: Marshall Co: Middle River at Old Mill State Park, 11 mi E of Argyle, T 156 R 46 S 4.
Long: 96° 35' 08" Lat: 48° 21' 32"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	12	5
2. NUMBER OF BENTHIC INSECTIVORES	2	1
3. EVENNESS	0.802	5
4. NUMBER OF MINNOW SPECIES	7	5
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	66.1%	1
7. PROPORTION OF INSECTIVORE BIOMASS	33.9%	3
8. PROPORTION OF SIMPLE LITHOPHILS	25.6%	1
9. PROPORTION OF TOLERANT SPECIES	51.2%	3
10. NUMBER OF SENSITIVE SPECIES	2	3
11. NUMBER OF INDIVIDUALS/METER	6.56	3
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		36

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-420 Drainage Area: 70 mi^2 Date:7-22-1993

Site: MN: Marshall Co: Snake River at CR 136 bridge, 7.5 mi E of Warren, T 155 R 46 S 29. Long: 96° 36' 28" Lat: 48° 12' 43"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	5
2. PROPORTION OF HEADWATER SPECIES	37.0%	3
3. EVENNESS	0.598	1
4. NUMBER OF MINNOW SPECIES	5	5
5. PROPORTION OF OMNIVORE BIOMASS	61.6%	3
6. PROPORTION OF INSECTIVORE BIOMASS	38.4%	3
7. PROPORTION OF SIMPLE LITHOPHILS	6.0%	1
8. PROPORTION OF TOLERANT SPECIES	61.4%	1
9. NUMBER OF SENSITIVE SPECIES	1	1
10. PROPORTION OF PIONEER SPECIES	56.5%	3
11. NUMBER OF INDIVIDUALS/METER	3.68	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		32

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number:93-421 Drainage Area: 60 mi^2 Date: 7-23-1996

Site: MN: Pennington Co: Black River at CR 55 bridge, 10.25 mi W of St. Hilaire, T 152 R 45 S 4. Long: 96° 25' 51" Lat: 48° 00' 28"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	4	3
2. PROPORTION OF HEADWATER SPECIES	85.7%	5
3. EVENNESS	0.73	3
4. NUMBER OF MINNOW SPECIES	2	1
5. PROPORTION OF OMNIVORE BIOMASS	0.0%	5
6. PROPORTION OF INSECTIVORE BIOMASS	100.0%	5
7. PROPORTION OF SIMPLE LITHOPHILS	24.5%	1
8. PROPORTION OF TOLERANT SPECIES	14.3%	1
9. NUMBER OF SENSITIVE SPECIES	2	3
10. PROPORTION OF PIONEER SPECIES	0.0%	5
11. NUMBER OF INDIVIDUALS/METER	0.98	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		38

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-422 Drainage Area: 271 mi^2 Date: 7-23-1993

Site: MN: Red Lake Co: Lost River at TR bridge, 2 mi NE of Brooks, T 151 R 42 S 36. Long: 95° 58' 37" Lat: 47° 50' 53"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	13	5
2. NUMBER OF BENTHIC INSECTIVORES	6	3
3. EVENNESS	0.718	3
4. NUMBER OF MINNOW SPECIES	6	3
5. PROPORTION OF PISCIVORE BIOMASS	15.2%	3
6. PROPORTION OF OMNIVORE BIOMASS	43.9%	3
7. PROPORTION OF INSECTIVORE BIOMASS	40.9%	3
8. PROPORTION OF SIMPLE LITHOPHILS	8.4%	1
9. PROPORTION OF TOLERANT SPECIES	35.3%	3
10. NUMBER OF SENSITIVE SPECIES	3	3
11. NUMBER OF INDIVIDUALS/METER	2.38	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		36

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number:93-423 Drainage Area: 174 mi^2 Date: 7-23-1993

Site: MN: Red Lake Co: Hill River, CR at junction 92, 2.5 mi E Brooks, T 150 R 41 S 17. Long: 95° 56' 55" Lat: 47° 49' 08"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	14	5
2. PROPORTION OF HEADWATER SPECIES	19.6%	1
3. EVENNESS	0.782	3
4. NUMBER OF MINNOW SPECIES	7	5
5. PROPORTION OF OMNIVORE BIOMASS	31.8%	5
6. PROPORTION OF INSECTIVORE BIOMASS	50.6%	3
7. PROPORTION OF SIMPLE LITHOPHILS	25.8%	1
8. PROPORTION OF TOLERANT SPECIES	40.2%	3
9. NUMBER OF SENSITIVE SPECIES	2	3
10. PROPORTION OF PIONEER SPECIES	27.3%	5
11. NUMBER OF INDIVIDUALS/METER	3.88	3
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		42

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number:93-424 Drainage Area: 100 mi^2 Date: 7-23-1993

Site: MN: Red Lake Co: Poplar River at CR 7 bridge, 3 mi S of Brooks, T 150 R 42 S 34. Long: 96° 01' 46" Lat: 47° 46' 28"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	8	3
2. PROPORTION OF HEADWATER SPECIES	19.0%	1
3. EVENNESS	0.776	3
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF OMNIVORE BIOMASS	0.3%	5
6. PROPORTION OF INSECTIVORE BIOMASS	99.7%	5
7. PROPORTION OF SIMPLE LITHOPHILS	13.9%	1
8. PROPORTION OF TOLERANT SPECIES	44.3%	3
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	20.3%	5
11. NUMBER OF INDIVIDUALS/METER	1.58	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		36

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-425 Drainage Area: 140 mi^2 Date: 7-23-1993

Site: MN: Red Lake Co: Lower Badger Creek at CR 11 bridge, 3 mi SW of Terrebonne, T 150 R 43 S 18. Long: 96° 12' 34" Lat: 47° 49" 03"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. PROPORTION OF HEADWATER SPECIES	30.5%	3
3. EVENNESS	0.778	3
4. NUMBER OF MINNOW SPECIES	5	3
5. PROPORTION OF OMNIVORE BIOMASS	38.5%	3
6. PROPORTION OF INSECTIVORE BIOMASS	61.5%	5
7. PROPORTION OF SIMPLE LITHOPHILS	35.8%	3
8. PROPORTION OF TOLERANT SPECIES	53.0%	3
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	17.9%	5
11. NUMBER OF INDIVIDUALS/METER	3.02	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		38

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-001 Drainage Area: 375 mi^2 Date: 6-22-1994

Site: MN: Traverse Co: West Branch Mustinka Creek, 0.15 mi west of CR 13, T 127 R 45 S 30. Long: 96° 22' 01" Lat: 45° 47' 19"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	6	1
2. NUMBER OF BENTHIC INSECTIVORES	1	1
3. EVENNESS	0.674	3
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	61.5%	1
7. PROPORTION OF INSECTIVORE BIOMASS	38.5%	1
8. PROPORTION OF SIMPLE LITHOPHILS	13.5%	1
9. PROPORTION OF TOLERANT SPECIES	57.0%	3
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	4.58	3
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		22*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-002 Drainage Area: 190 mi^2 Date: 6-22-1994

Site: MN: Wilkin Co: Rabbit River at TR bridge, 2.25 mi W of River Center, T 130 R 45 S 8.
Long: 96° 21' 14" Lat: 46° 04' 45"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	6	3
2. PROPORTION OF HEADWATER SPECIES	6.7%	1
3. EVENNESS	0.422	1
4. NUMBER OF MINNOW SPECIES	0	1
5. PROPORTION OF OMNIVORE BIOMASS	98.7%	1
6. PROPORTION OF INSECTIVORE BIOMASS	1.3%	1
7. PROPORTION OF SIMPLE LITHOPHILS	86.7%	5
8. PROPORTION OF TOLERANT SPECIES	85.3%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	0.0%	5
11. NUMBER OF INDIVIDUALS/METER	0.73	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		26

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-004 Drainage Area: 107 mi^2 Date: 6-23-1994

Site: MN: Wilkin Co: South Branch Buffalo River upstream of Wilkin CR 188, T 136 R 46 S 18.
Long: 96° 36' 12" Lat: 46° 36' 53"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	3	1
2. PROPORTION OF HEADWATER SPECIES	0.0%	1
3. EVENNESS	0.527	1
4. NUMBER OF MINNOW SPECIES	0	1
5. PROPORTION OF OMNIVORE BIOMASS	99.6%	1
6. PROPORTION OF INSECTIVORE BIOMASS	0.4%	1
7. PROPORTION OF SIMPLE LITHOPHILS	16.1%	1
8. PROPORTION OF TOLERANT SPECIES	96.8%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	0.0%	1
11. NUMBER OF INDIVIDUALS/METER	0.31	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		16*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-005 Drainage Area: 120 mi^2 Date:6-23-1994

Site: MN: Clay Co: Whiskey Creek at CR 57, T 137 R 47 S 13. Long: 96° 33' 35" Lat: 46° 41' 19"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	4	1
2. PROPORTION OF HEADWATER SPECIES	0.0%	1
3. EVENNESS	0.726	3
4. NUMBER OF MINNOW SPECIES	2	1
5. PROPORTION OF OMNIVORE BIOMASS	99.6%	1
6. PROPORTION OF INSECTIVORE BIOMASS	0.4%	1
7. PROPORTION OF SIMPLE LITHOPHILS	64.7%	1
8. PROPORTION OF TOLERANT SPECIES	100.0%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	11.8%	1
11. NUMBER OF INDIVIDUALS/METER	0.15	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		18*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-006 Drainage Area: 137 mi^2 Date:6-24-1994

Site: MN: Clay Co: Stony Creek at Cty. Rd. 21, 1.5 mi from Baker, T 138 R 46 S 31. Long: 96° 32' 49" Lat: 46° 43' 08"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	3	1
2. PROPORTION OF HEADWATER SPECIES	0.0%	1
3. EVENNESS	1	5
4. NUMBER OF MINNOW SPECIES	0	1
5. PROPORTION OF OMNIVORE BIOMASS	21.0%	1
6. PROPORTION OF INSECTIVORE BIOMASS	0.0%	1
7. PROPORTION OF SIMPLE LITHOPHILS	66.7%	1
8. PROPORTION OF TOLERANT SPECIES	33.3%	3
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	0.0%	1
11. NUMBER OF INDIVIDUALS/METER	0.03	1
12. PERCENT DELT	0.0%	5
	TOTAL IBI SCORE	22*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-007 Drainage Area: 420 mi^2 Date: 6-28-1994

Site: MN: Kittson Co: South Branch Two Rivers at CR 15/HWY 59 bridge, Lake Bronson, T 161 R 46 S 31. Long: 96° 40' 04" Lat: 48° 43' 54"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	13	5
2. NUMBER OF BENTHIC INSECTIVORES	3	1
3. EVENNESS	0.653	3
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF PISCIVORE BIOMASS	2.8%	1
6. PROPORTION OF OMNIVORE BIOMASS	47.5%	3
7. PROPORTION OF INSECTIVORE BIOMASS	49.7%	3
8. PROPORTION OF SIMPLE LITHOPHILS	66.6%	5
9. PROPORTION OF TOLERANT SPECIES	59.1%	1
10. NUMBER OF SENSITIVE SPECIES	1	1
11. NUMBER OF INDIVIDUALS/METER	7.42	5
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		36

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-008 Drainage Area: 255 mi^2 Date: 6-29-1993

Site: MN: Marshall Co: Middle River at CR 4 bridge, 0.25 mi E of Argyle, T 156 R 48 S 15. Long: 96° 48' 40" Lat: 48° 20' 16"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	13	5
2. NUMBER OF BENTHIC INSECTIVORES	4	3
3. EVENNESS	0.602	3
4. NUMBER OF MINNOW SPECIES	6	3
5. PROPORTION OF PISCIVORE BIOMASS	13.9%	3
6. PROPORTION OF OMNIVORE BIOMASS	72.5%	1
7. PROPORTION OF INSECTIVORE BIOMASS	13.7%	1
8. PROPORTION OF SIMPLE LITHOPHILS	36.3%	3
9. PROPORTION OF TOLERANT SPECIES	88.2%	1
10. NUMBER OF SENSITIVE SPECIES	2	3
11. NUMBER OF INDIVIDUALS/METER	4.48	3
12. PERCENT DELT	0.5%	5
TOTAL IBI SCORE		34

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-009 Drainage Area: 420 mi^2 Date: 6-29-1994

Site: MN: Kittson Co: South Branch Two Rivers at CR 15/HWY 59 bridge, Lake Bronson, T 161 R 46 S 31. Long: 96° 40' 04" Lat: 48° 43' 54"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	11	3
2. NUMBER OF BENTHIC INSECTIVORES	3	1
3. EVENNESS	0.747	3
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF PISCIVORE BIOMASS	5.1%	1
6. PROPORTION OF OMNIVORE BIOMASS	28.4%	5
7. PROPORTION OF INSECTIVORE BIOMASS	66.5%	5
8. PROPORTION OF SIMPLE LITHOPHILS	61.4%	5
9. PROPORTION OF TOLERANT SPECIES	61.4%	1
10. NUMBER OF SENSITIVE SPECIES	1	1
11. NUMBER OF INDIVIDUALS/METER	2.72	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		32

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-010 Drainage Area: 220 mi^2 Date: 6-29-1994

Site: MN: Roseau Co: South Fork Roseau River at Twp. Rd. 0.75 mi E of Hwy 89, T 161 R 40 S 13.
Long: 95° 41' 43" Lat: 48° 35' 03"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	13	5
2. NUMBER OF BENTHIC INSECTIVORES	3	3
3. EVENNESS	0.763	3
4. NUMBER OF MINNOW SPECIES	7	5
5. PROPORTION OF PISCIVORE BIOMASS	17.8%	3
6. PROPORTION OF OMNIVORE BIOMASS	47.7%	3
7. PROPORTION OF INSECTIVORE BIOMASS	34.5%	3
8. PROPORTION OF SIMPLE LITHOPHILS	21.7%	1
9. PROPORTION OF TOLERANT SPECIES	34.1%	3
10. NUMBER OF SENSITIVE SPECIES	2	3
11. NUMBER OF INDIVIDUALS/METER	4.23	3
12. PERCENT DELT	0.5%	5
TOTAL IBI SCORE		40

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-011 Drainage Area: 65 mi^2 Date: 08-01-1994

Site: MN: Clay Co: Hay Creek, 1 mi S of CR 71, T 138 R 46 S 11. Long: 96° 26' 47" Lat: 46° 46' 33"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	6	3
2. PROPORTION OF HEADWATER SPECIES	24.2%	1
3. EVENNESS	0.687	3
4. NUMBER OF MINNOW SPECIES	2	1
5. PROPORTION OF OMNIVORE BIOMASS	47.7%	3
6. PROPORTION OF INSECTIVORE BIOMASS	52.3%	3
7. PROPORTION OF SIMPLE LITHOPHILS	53.5%	3
8. PROPORTION OF TOLERANT SPECIES	74.7%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	16.2%	5
11. NUMBER OF INDIVIDUALS/METER	0.94	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		30

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-012 Drainage Area: 185 mi^2 Date: 08-02-1994

Site: MN: Clay Co: South Branch Wild Rice River, E of CSAH 27 bridge, T 142 R 45 S 16. Long: 96° 24' 08" Lat: 47° 07' 01"

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	20	5
2. PROPORTION OF HEADWATER SPECIES	17.0%	1
3. EVENNESS	0.744	3
4. NUMBER OF MINNOW SPECIES	10	5
5. PROPORTION OF OMNIVORE BIOMASS	32.7%	5
6. PROPORTION OF INSECTIVORE BIOMASS	58.8%	3
7. PROPORTION OF SIMPLE LITHOPHILS	49.9%	3
8. PROPORTION OF TOLERANT SPECIES	49.5%	3
9. NUMBER OF SENSITIVE SPECIES	7	5
10. PROPORTION OF PIONEER SPECIES	27.0%	5
11. NUMBER OF INDIVIDUALS/METER	3.52	1
12. PERCENT DELT	0 0%	5
	TOTAL IBI SCORE	44

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-013 Drainage Area: 207 mi^2 Date: 08-02-1994

Site: MN: Norman Co: South Branch Wild Rice River, W of CR 136 bridge, T 143 R 46 S 30.
Long: 96° 33' 35" Lat: 47° 10' 15"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	21	5
2. NUMBER OF BENTHIC INSECTIVORES	10	5
3. EVENNESS	0.659	3
4. NUMBER OF MINNOW SPECIES	11	5
5. PROPORTION OF PISCIVORE BIOMASS	20.8%	5
6. PROPORTION OF OMNIVORE BIOMASS	9.4%	5
7. PROPORTION OF INSECTIVORE BIOMASS	69.8%	5
8. PROPORTION OF SIMPLE LITHOPHILS	20.5%	1
9. PROPORTION OF TOLERANT SPECIES	48.4%	3
10. NUMBER OF SENSITIVE SPECIES	8	5
11. NUMBER OF INDIVIDUALS/METER	1.91	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		48

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-014 Drainage Area: 223 mi^2 Date: 08-02-1994

Site: MN: Norman Co: Marsh River, N of CR129 bridge, T 146 R 48 S 34. Long: 96° 45' 58" Lat: 47° 24' 44"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	17	5
2. NUMBER OF BENTHIC INSECTIVORES	5	3
3. EVENNESS	0.749	3
4. NUMBER OF MINNOW SPECIES	9	5
5. PROPORTION OF PISCIVORE BIOMASS	36.2%	3
6. PROPORTION OF OMNIVORE BIOMASS	26.5%	5
7. PROPORTION OF INSECTIVORE BIOMASS	37.3%	3
8. PROPORTION OF SIMPLE LITHOPHILS	10.1%	1
9. PROPORTION OF TOLERANT SPECIES	59.7%	3
10. NUMBER OF SENSITIVE SPECIES	3	3
11. NUMBER OF INDIVIDUALS/METER	3.08	1
12. PERCENT DELT	0.2%	5
TOTAL IBI SCORE		40

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-015 Drainage Area: 380 mi^2 Date: 08-03-1994

Site: MN: Clay Co: Buffalo River at Buffalo State Park, 0.2 mi below dam, T 139 R 46 S 10. Long: 96° 28' 09" Lat: 46° 51' 44"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	26	5
2. NUMBER OF BENTHIC INSECTIVORES	10	5
3. EVENNESS	0.751	3
4. NUMBER OF MINNOW SPECIES	10	5
5. PROPORTION OF PISCIVORE BIOMASS	15.0%	3
6. PROPORTION OF OMNIVORE BIOMASS	58.9%	3
7. PROPORTION OF INSECTIVORE BIOMASS	26.1%	1
8. PROPORTION OF SIMPLE LITHOPHILS	27.8%	1
9. PROPORTION OF TOLERANT SPECIES	44.6%	3
10. NUMBER OF SENSITIVE SPECIES	11	5
11. NUMBER OF INDIVIDUALS/METER	0.96	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		40

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-016 Drainage Area: 1,524 mi^2 Date: 09-07-1994

Site: MN: Norman Co: Wild Rice River at Leon Burgen Clubhouse, 0.5 mi E of CR 6, T 143 R 48 S 14.
Long: 96° 43' 14" Lat: 47° 11' 54"

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	23	5
2. PROPORTION OF LARGE RIVER SPECIES	28.7%	3
3. PROPORTION OF ROUND BODIED SUCKERS	15.4%	1
4. EVENNESS	0.856	5
5. PROPORTION OF PISCIVORE BIOMASS	39.1%	3
6. PROPORTION OF OMNIVORE BIOMASS	48.6%	3
7. PROPORTION OF INSECTIVORE BIOMASS	12.3%	1
8. PROPORTION OF SIMPLE LITHOPHILS	21.7%	1
9. PROPORTION OF TOLERANT SPECIES	33.6%	3
10. NUMBER OF SENSITIVE SPECIES	9	5
11. NUMBER OF INDIVIDUALS/METER	0.48	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		36

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-017 Drainage Area: 1,613 mi^2 Date: 09-07-1994

Site: MN: Norman Co: Wild Rice River, 0.5 mi W of end of CR 109, T 146 R 49 S 12. Long: 96° 50' 09" Lat: 47° 19' 01"

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	21	5
2. PROPORTION OF LARGE RIVER SPECIES	48.1%	5
3. PROPORTION OF ROUND BODIED SUCKERS	7.5%	1
4. EVENNESS	0.787	3
5. PROPORTION OF PISCIVORE BIOMASS	18.0%	3
6. PROPORTION OF OMNIVORE BIOMASS	51.6%	3
7. PROPORTION OF INSECTIVORE BIOMASS	30.3%	3
8. PROPORTION OF SIMPLE LITHOPHILS	11.3%	1
9. PROPORTION OF TOLERANT SPECIES	23.3%	5
10. NUMBER OF SENSITIVE SPECIES	9	5
11. NUMBER OF INDIVIDUALS/METER	1.77	1
12. PERCENT DELT	0 0%	5
TOTAL IBI SCORE		40

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-018 Drainage Area: 16,753 mi^2 Date: 09-07-1994

Site: MN: Norman Co: Red River, 0.5 mi W of end of CR 109, T 144 R 48 S 1. Long: 96° 49' 45" Lat: 47° 19' 35"

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	24	5
2. PROPORTION OF LARGE RIVER SPECIES	37.5%	3
3. PROPORTION OF ROUND BODIED SUCKERS	12.5%	1
4. EVENNESS	0.868	5
5. PROPORTION OF PISCIVORE BIOMASS	22.5%	5
6. PROPORTION OF OMNIVORE BIOMASS	20.5%	5
7. PROPORTION OF INSECTIVORE BIOMASS	56.8%	3
8. PROPORTION OF SIMPLE LITHOPHILS	17.5%	1
9. PROPORTION OF TOLERANT SPECIES	18.8%	5
10. NUMBER OF SENSITIVE SPECIES	9	5
11. NUMBER OF INDIVIDUALS/METER	0.32	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		44

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-019 Drainage Area: 1025 mi^2 Date: 09-08-1994

Site: MN: Clay Co: Buffalo River at CR 26, 2.5 mi E of Kragnes, T 141 R 48 S 36. Long: 96° 41' 26" Lat: 46° 58' 39"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	21	5
2. NUMBER OF BENTHIC INSECTIVORES	5	3
3. EVENNESS	0.872	5
4. NUMBER OF MINNOW SPECIES	5	3
5. PROPORTION OF PISCIVORE BIOMASS	14.3%	3
6. PROPORTION OF OMNIVORE BIOMASS	51.5%	3
7. PROPORTION OF INSECTIVORE BIOMASS	34.0%	3
8. PROPORTION OF SIMPLE LITHOPHILS	34.0%	3
9. PROPORTION OF TOLERANT SPECIES	20.6%	5
10. NUMBER OF SENSITIVE SPECIES	7	5
11. NUMBER OF INDIVIDUALS/METER	0.39	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		44

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-020 Drainage Area: 3,890 mi^2 Date: 09-08-1994

Site: MN: Wilkin Co: Red River, Downstream of Hwy. 210, below power plant, T 133 R 47 S 33. Long: 96° 36' 17" Lat: 46° 17' 40"

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	18	5
2. PROPORTION OF LARGE RIVER SPECIES	23.6%	3
3. PROPORTION OF ROUND BODIED SUCKERS	4.4%	1
4. EVENNESS	0.527	1
5. PROPORTION OF PISCIVORE BIOMASS	50.6%	1
6. PROPORTION OF OMNIVORE BIOMASS	29.9%	5
7. PROPORTION OF INSECTIVORE BIOMASS	19.1%	1
8. PROPORTION OF SIMPLE LITHOPHILS	5.0%	1
9. PROPORTION OF TOLERANT SPECIES	8.7%	5
10. NUMBER OF SENSITIVE SPECIES	5	3
11. NUMBER OF INDIVIDUALS/METER	0.69	1
12. PERCENT DELT	0.3%	5
TOTAL IBI SCORE		32

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-021 Drainage Area: 3895 mi^2 Date: 09-20-1994

Site: MN: Wilkin Co: Red River, 0.5 mi W of Hwy 75, T 133 R 47 S 21. Long: 96° 36' 03" Lat: 46° 19' 36"

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	16	3
2. PROPORTION OF LARGE RIVER SPECIES	31.3%	3
3. PROPORTION OF ROUND BODIED SUCKERS	46.1%	5
4. EVENNESS	0.711	3
5. PROPORTION OF PISCIVORE BIOMASS	17.1%	3
6. PROPORTION OF OMNIVORE BIOMASS	2.1%	5
7. PROPORTION OF INSECTIVORE BIOMASS	80.8%	5
8. PROPORTION OF SIMPLE LITHOPHILS	49.6%	3
9. PROPORTION OF TOLERANT SPECIES	12.2%	5
10. NUMBER OF SENSITIVE SPECIES	5	3
11. NUMBER OF INDIVIDUALS/METER	0.23	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		44

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-022 Drainage Area: 1925 mi^2 Date: 09-09-1994

Site: MN: Wilkin Co: Ottertail River, adjacent to CR 14, T 132 R 46 S 18. Long: 96° 29' 32" Lat: 46° 15' 04"

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	25	5
2. PROPORTION OF LARGE RIVER SPECIES	3.4%	1
3. PROPORTION OF ROUND BODIED SUCKERS	9.1%	1
4. EVENNESS	0.785	3
5. PROPORTION OF PISCIVORE BIOMASS	2.8%	1
6. PROPORTION OF OMNIVORE BIOMASS	70.9%	1
7. PROPORTION OF INSECTIVORE BIOMASS	25.8%	1
8. PROPORTION OF SIMPLE LITHOPHILS	17.3%	1
9. PROPORTION OF TOLERANT SPECIES	39.0%	3
10. NUMBER OF SENSITIVE SPECIES	8	5
11. NUMBER OF INDIVIDUALS/METER	1.25	1
12. PERCENT DELT	0.3%	5
TOTAL IBI SCORE		28

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-506 Drainage Area: 3,580 mi^2 Date: 09-03-1994

Site: MN: Red Lake Co: Red Lake River, USGS site at Red Lake Falls, field # 47533109, T 151 R 44 S 13. Long: 96° 14' 46" Lat: 47° 55' 31"

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	23	5
2. PROPORTION OF LARGE RIVER SPECIES	5.4%	1
3. PROPORTION OF ROUND BODIED SUCKERS	19.4%	1
4. EVENNESS	0.79	3
5. PROPORTION OF PISCIVORE BIOMASS	12.5%	3
6. PROPORTION OF OMNIVORE BIOMASS	7.1%	5
7. PROPORTION OF INSECTIVORE BIOMASS	80.4%	5
8. PROPORTION OF SIMPLE LITHOPHILS	43.6%	3
9. PROPORTION OF TOLERANT SPECIES	12.4%	5
10. NUMBER OF SENSITIVE SPECIES	9	5
11. NUMBER OF INDIVIDUALS/METER	1.40	1
12. PERCENT DELT	0.3%	5
TOTAL IBI SCORE		42

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-507 Drainage Area: 380 mi^2 Date: 08-12-1994

Site: MN: Clay Co: Buffalo River, USGS site near Buffalo River State Park, Field # 46514909, T 139 R 46 S 11. Long: 96° 28' 04" Lat: 46° 51'49"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	20	5
2. NUMBER OF BENTHIC INSECTIVORES	9	5
3. EVENNESS	0.602	3
4. NUMBER OF MINNOW SPECIES	10	5
5. PROPORTION OF PISCIVORE BIOMASS	12.7%	3
6. PROPORTION OF OMNIVORE BIOMASS	40.0%	3
7. PROPORTION OF INSECTIVORE BIOMASS	47.4%	3
8. PROPORTION OF SIMPLE LITHOPHILS	27.0%	1
9. PROPORTION OF TOLERANT SPECIES	11.8%	5
10. NUMBER OF SENSITIVE SPECIES	9	5
11. NUMBER OF INDIVIDUALS/METER	3.23	3
12. PERCENT DELT	1.6%	3
TOTAL IBI SCORE		44

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-508 Drainage Area: 446 mi^2 Date: 08-22-1994

Site: MN: Kittson Co: South Branch Two Rivers, USGS site at Lake Bronson, field # 5094000, T 161 R 46 S 30 Long: 96° 39' 50" Lat: 48° 43' 50"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. NUMBER OF BENTHIC INSECTIVORES	4	3
3. EVENNESS	0.699	3
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	33.1%	3
7. PROPORTION OF INSECTIVORE BIOMASS	66.9%	5
8. PROPORTION OF SIMPLE LITHOPHILS	32.9%	3
9. PROPORTION OF TOLERANT SPECIES	36.6%	3
10. NUMBER OF SENSITIVE SPECIES	2	1
11. NUMBER OF INDIVIDUALS/METER	5.19	3
12. PERCENT DELT	1.3%	3
TOTAL IBI SCORE		34

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-509 Drainage Area: 218 mi^2 Date: 08-10-1994

Site: MN: Polk Co: Snake River, USGS site near Alvarado, field # 5085900, reach 3, T 154 R 49 S 8. Long: 97° 00' 20" Lat: 48° 11' 50"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	6	3
2. NUMBER OF BENTHIC INSECTIVORES	1	1
3. EVENNESS	0.916	5
4. NUMBER OF MINNOW SPECIES	2	1
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	13.9%	5
7. PROPORTION OF INSECTIVORE BIOMASS	86.1%	5
8. PROPORTION OF SIMPLE LITHOPHILS	15.4%	1
9. PROPORTION OF TOLERANT SPECIES	73.1%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	0.17	1
12. PERCENT DELT	3.8%	3
TOTAL IBI SCORE		28

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-510 Drainage Area: 218 mi^2 Date: 08-10-1994

Site: MN: Polk Co: Snake River, USGS site near Alvarado, field # 5085900, reach 2, T 154 R 49 S 8. Long: 97° 00' 20" Lat: 48° 11' 50"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	7	3
2. NUMBER OF BENTHIC INSECTIVORES	2	1
3. EVENNESS	0.863	5
4. NUMBER OF MINNOW SPECIES	2	1
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	65.0%	3
7. PROPORTION OF INSECTIVORE BIOMASS	35.0%	3
8. PROPORTION OF SIMPLE LITHOPHILS	19.6%	1
9. PROPORTION OF TOLERANT SPECIES	82.1%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	0.37	1
12. PERCENT DELT	1.8%	3
TOTAL IBI SCORE		24

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-511 Drainage Area: 218 mi^2 Date: 08-10-1994

Site: MN: Polk Co: Snake River, USGS site near Alvarado, field # 5085900, reach 1, T 154 R 49 S 8. Long: 97° 00' 20" Lat: 48° 11' 50"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	6	3
2. NUMBER OF BENTHIC INSECTIVORES	1	1
3. EVENNESS	0.912	5
4. NUMBER OF MINNOW SPECIES	2	1
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	47.6%	3
7. PROPORTION OF INSECTIVORE BIOMASS	52.4%	3
8. PROPORTION OF SIMPLE LITHOPHILS	21.4%	1
9. PROPORTION OF TOLERANT SPECIES	76.2%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	0.28	1
12. PERCENT DELT	0.0%	5
TOTAL IBI SCORE		26

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-512 Drainage Area: 1,358mi^2 Date: 08-24-1994

Site: MN: Red Lake Co: Clearwater River, USGS site at Red Lake Falls, field # 0507850, T 151 R 44 S 22.
Long: 96° 16' 25" Lat: 47° 53' 15"

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	12	3
2. NUMBER OF BENTHIC INSECTIVORES	5	3
3. EVENNESS	0.856	5
4. NUMBER OF MINNOW SPECIES	6	3
5. PROPORTION OF PISCIVORE BIOMASS	74.5%	1
6. PROPORTION OF OMNIVORE BIOMASS	0.3%	5
7. PROPORTION OF INSECTIVORE BIOMASS	25.2%	1
8. PROPORTION OF SIMPLE LITHOPHILS	46.4%	3
9. PROPORTION OF TOLERANT SPECIES	18.6%	5
10. NUMBER OF SENSITIVE SPECIES	6	5
11. NUMBER OF INDIVIDUALS/METER	1.22	1
12. PERCENT DELT	2.7%	3
TOTAL IBI SCORE		38

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-513 Drainage Area: 5,270 mi^2 Date: 08-31-1994

Site: MN: Polk Co: Red Lake River, USGS site at Crookston, field # 05079000, T 150 R 46 S 30. Long: 96° 36' 33" Lat: 47° 46' 32"

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	20	5
2. PROPORTION OF LARGE RIVER SPECIES	3.5%	1
3. PROPORTION OF ROUND BODIED SUCKERS	0.5%	1
4. EVENNESS	0.526	1
5. PROPORTION OF PISCIVORE BIOMASS	69.2%	1
6. PROPORTION OF OMNIVORE BIOMASS	15.8%	5
7. PROPORTION OF INSECTIVORE BIOMASS	14.8%	1
8. PROPORTION OF SIMPLE LITHOPHILS	1.6%	1
9. PROPORTION OF TOLERANT SPECIES	62.8%	1
10. NUMBER OF SENSITIVE SPECIES	7	5
11. NUMBER OF INDIVIDUALS/METER	2.74	5
12. PERCENT DELT	0.3%	5
TOTAL IBI SCORE		32

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-532 Drainage Area: 1,880 mi^2 Date: 08-14-1994

Site: MN: Wilkin Co: Bois de Sioux River, USGS near Doran, CSAH 6, field # 05051200, T 131 R 47 S 21. Long: 96° 34' 46" Lat: 46° 09' 08"

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	14	3
2. PROPORTION OF LARGE RIVER SPECIES	24.8%	3
3. PROPORTION OF ROUND BODIED SUCKERS	0.1%	1
4. EVENNESS	0.471	1
5. PROPORTION OF PISCIVORE BIOMASS	0.0%	1
6. PROPORTION OF OMNIVORE BIOMASS	90.5%	1
7. PROPORTION OF INSECTIVORE BIOMASS	9.5%	1
8. PROPORTION OF SIMPLE LITHOPHILS	1.4%	1
9. PROPORTION OF TOLERANT SPECIES	70.9%	1
10. NUMBER OF SENSITIVE SPECIES	2	1
11. NUMBER OF INDIVIDUALS/METER	4.73	5
12. PERCENT DELT	0.6%	5
TOTAL IBI SCORE		24

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-408 Drainage Area: 160 mi^2 Date: 7-21-1993

Site: ND: Pembina Co: Tongue River below Renwick Dam, 6 mi W Cavalier.
Long: 97° 43' 40.2" Lat: 48° 46' 40".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	8	3
2. PROPORTION OF HEADWATER SPECIES	9.5%	1
3. EVENNESS	0.595	3
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF OMNIVORE BIOMASS	85.5%	1
6. PROPORTION OF INSECTIVORE BIOMASS	12.6%	1
7. PROPORTION OF SIMPLE LITHOPHILS	79%	5
8. PROPORTION OF TOLERANT SPECIES	84.8%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	11.4%	5
11. NUMBER OF INDIVIDUALS/METER	2.1	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		28

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-409 Drainage Area: 295 mi^2 Date: 7-21-1993

Site: ND: Pembina Co: Tongue River at Hwy 18, 3.25 mi SW Bathgate.
Long: 97° 33' 21.6" Lat: 48° 51' 06".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	7	3
2. NUMBER OF BENTHIC INSECTIVORES	1	1
3. EVENNESS	0.812	5
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF PISCIVORE BIOMASS	0	1
6. PROPORTION OF OMNIVORE BIOMASS	29.4%	5
7. PROPORTION OF INSECTIVORE BIOMASS	.706	5
8. PROPORTION OF SIMPLE LITHOPHILS	37.5%	3
9. PROPORTION OF TOLERANT SPECIES	70.5%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	1.76	1
12. PERCENT DELT	1.1%	3
TOTAL IBI SCORE		30

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-410 Drainage Area: 3300 mi^2 Date: 7-21-1993

Site: ND: Pembina Co: Pembina River, County Road 12 bridge, 0.5 mi N Leroy.
Long: 97° 45' 07.1" Lat: 48° 55' 59".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	12	3
2. PROPORTION OF LARGE RIVER SPECIES	0	1
3. PROPORTION OF ROUND BODIED SUCKERS	3%	1
4. EVENNESS	0.64	3
5. PROPORTION OF PISCIVORE BIOMASS	7%	1
6. PROPORTION OF OMNIVORE BIOMASS	1.1%	5
7. PROPORTION OF INSECTIVORE BIOMASS	97.5%	5
8. PROPORTION OF SIMPLE LITHOPHILS	4.9%	1
9. PROPORTION OF TOLERANT SPECIES	20.9%	5
10. NUMBER OF SENSITIVE SPECIES	4	3
11. NUMBER OF INDIVIDUALS/METER	2.6	3
12. PERCENT DELT	0	5
TOTAL IBI SCORE		36

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-411 Drainage Area: 3200 mi^2 Date: 7-21-1993

Site: ND: Pembina Co: Pembina River, SH 32 bridge, 0.75 mi SW Walhalla.
Long: 97° 55' 01" Lat: 48° 54' 91".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	13	3
2. PROPORTION OF LARGE RIVER SPECIES	0	1
3. PROPORTION OF ROUND BODIED SUCKERS	0	1
4. EVENNESS	0.705	3
5. PROPORTION OF PISCIVORE BIOMASS	15.7%	3
6. PROPORTION OF OMNIVORE BIOMASS	17.1%	5
7. PROPORTION OF INSECTIVORE BIOMASS	63.7%	5
8. PROPORTION OF SIMPLE LITHOPHILS	17.2%	1
9. PROPORTION OF TOLERANT SPECIES	33.6%	3
10. NUMBER OF SENSITIVE SPECIES	4	3
11. NUMBER OF INDIVIDUALS/METER	1.44	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		34

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-412 Drainage Area: 66 mi^2 Date: 7-21-1993

Site: ND: Pembina Co: North Branch Park River, SH 32 bridge, 6 mi N Edinburg.
Long: 97° 51' 42" Lat: 48° 35' 26".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	5	3
2. PROPORTION OF HEADWATER SPECIES	80.9%	5
3. EVENNESS	0.499	1
4. NUMBER OF MINNOW SPECIES	3	3
5. PROPORTION OF OMNIVORE BIOMASS	43.7%	3
6. PROPORTION OF INSECTIVORE BIOMASS	43.3%	3
7. PROPORTION OF SIMPLE LITHOPHILS	8.5%	1
8. PROPORTION OF TOLERANT SPECIES	99.8%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	18.9%	5
11. NUMBER OF INDIVIDUALS/METER	8.26	5
12. PERCENT DELT	0	5
TOTAL IBI SCORE		36

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-413 Drainage Area: 89 mi^2 Date: 7-21-1993

Site: ND: Walsh Co: South Branch Park River, SH 32 bridge, 5.5 mi W, 1.5 mi N Park River.
Long: 97° 51' 43" Lat: 48° 24' 52".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	8	3
2. PROPORTION OF HEADWATER SPECIES	48.7%	3
3. EVENNESS	0.685	3
4. NUMBER OF MINNOW SPECIES	5	3
5. PROPORTION OF OMNIVORE BIOMASS	19%	5
6. PROPORTION OF INSECTIVORE BIOMASS	81%	5
7. PROPORTION OF SIMPLE LITHOPHILS	53.4%	3
8. PROPORTION OF TOLERANT SPECIES	63.2%	1
9. NUMBER OF SENSITIVE SPECIES	1	1
10. PROPORTION OF PIONEER SPECIES	23.3%	5
11. NUMBER OF INDIVIDUALS/METER	3.86	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		38

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-414 Drainage Area: 157 mi^2 Date: 7-21-1993

Site: ND: Walsh Co: Middle Branch Forest River, SH 32 bridge, 3 mi W Fordville.
Long: 97° 51' 38" Lat: 48° 12' 43".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	3	1
2. PROPORTION OF HEADWATER SPECIES	0	1
3. EVENNESS	0.349	1
4. NUMBER OF MINNOW SPECIES	1	1
5. PROPORTION OF OMNIVORE BIOMASS	94.2%	1
6. PROPORTION OF INSECTIVORE BIOMASS	5.8%	1
7. PROPORTION OF SIMPLE LITHOPHILS	90.5%	1
8. PROPORTION OF TOLERANT SPECIES	98.6%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	9.5%	1
11. NUMBER OF INDIVIDUALS/METER	1.48	1
12. PERCENT DELT	0	5
	TOTAL IBI SCORE	16*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-415 Drainage Area: 416 mi^2 Date: 7-21-1993

Site: ND: Grand Forks Co: Forest River 2 mi N Inkster on bridge.
Long: 97° 38' 37" Lat: 48° 10' 46".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	12	3
2. NUMBER OF BENTHIC INSECTIVORES	5	3
3. EVENNESS	0.729	3
4. NUMBER OF MINNOW SPECIES	8	5
5. PROPORTION OF PISCIVORE BIOMASS	0	1
6. PROPORTION OF OMNIVORE BIOMASS	40.7%	3
7. PROPORTION OF INSECTIVORE BIOMASS	56.7%	3
8. PROPORTION OF SIMPLE LITHOPHILS	36.8%	3
9. PROPORTION OF TOLERANT SPECIES	46.3%	3
10. NUMBER OF SENSITIVE SPECIES	2	1
11. NUMBER OF INDIVIDUALS/METER	3.07	3
12. PERCENT DELT	0.3%	5
TOTAL IBI SCORE		36

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-427 Drainage Area: 148 mi^2 Date: 7-23-1993

Site: ND: Grand Forks Co: North Branch Turtle River, SH 18 bridge, 3 mi N US 2 Junct.
Long: 97° 37' 25" Lat: 47° 59' 31".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	8	3
2. PROPORTION OF HEADWATER SPECIES	41.8%	3
3. EVENNESS	0.721	3
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF OMNIVORE BIOMASS	30.6%	5
6. PROPORTION OF INSECTIVORE BIOMASS	66.2%	5
7. PROPORTION OF SIMPLE LITHOPHILS	45.5%	3
8. PROPORTION OF TOLERANT SPECIES	85.5%	1
9. NUMBER OF SENSITIVE SPECIES	1	1
10. PROPORTION OF PIONEER SPECIES	40%	3
11. NUMBER OF INDIVIDUALS/METER	0.73	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		36

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 93-428 Drainage Area: 34 mi^2 Date: 7-23-1993

Site: ND: Grand Forks Co: Little Goose River, 6 mi S, 3 mi W Larimore.
Long: 97° 41' 37" Lat: 47° 49' 01".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	3	3
2. PROPORTION OF HEADWATER SPECIES	22.9%	1
3. EVENNESS	0.554	1
4. NUMBER OF MINNOW SPECIES	1	1
5. PROPORTION OF OMNIVORE BIOMASS	92.2%	1
6. PROPORTION OF INSECTIVORE BIOMASS	7.8%	1
7. PROPORTION OF SIMPLE LITHOPHILS	0	1
8. PROPORTION OF TOLERANT SPECIES	98.6%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	75.7%	1
11. NUMBER OF INDIVIDUALS/METER	1.4	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		18

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-101 Drainage Area: 220 mi^2 Date: 7-26-1994

Site: ND: Walsh Co: Middle Branch Park River, .5 mi N, 5 mi E, .5 mi N Edinburg.
Long: 97° 45' 12" Lat: 48° 30' 30".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	8	3
2. NUMBER OF BENTHIC INSECTIVORES	2	1
3. EVENNESS	0.824	5
4. NUMBER OF MINNOW SPECIES	5	3
5. PROPORTION OF PISCIVORE BIOMASS	0	1
6. PROPORTION OF OMNIVORE BIOMASS	61.7%	3
7. PROPORTION OF INSECTIVORE BIOMASS	38.3%	3
8. PROPORTION OF SIMPLE LITHOPHILS	29.6%	1
9. PROPORTION OF TOLERANT SPECIES	92.1%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	23.1	5
12. PERCENT DELT	0.4%	5
TOTAL IBI SCORE		32

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-102 Drainage Area: 333 mi^2 Date: 7-27-1994

Site: ND: Grand Forks Co: Turtle River, 1 mi E, .5 mi S Middle Grove Church.
Long: 97° 14' 17" Lat: 48° 00' 50".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	12	5
2. NUMBER OF BENTHIC INSECTIVORES	4	3
3. EVENNESS	0.549	1
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF PISCIVORE BIOMASS	1.3%	1
6. PROPORTION OF OMNIVORE BIOMASS	81.4%	1
7. PROPORTION OF INSECTIVORE BIOMASS	17.3%	1
8. PROPORTION OF SIMPLE LITHOPHILS	7.4%	1
9. PROPORTION OF TOLERANT SPECIES	86.3%	1
10. NUMBER OF SENSITIVE SPECIES	1	1
11. NUMBER OF INDIVIDUALS/METER	2.63	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		24

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-103 Drainage Area: 138 mi^2 Date: 9-09-1994

Site: ND: Cass Co: Rush River, 4 mi N, 2 mi W, .5 mi N Mapleton.
Long: 97° 05' 36" Lat: 46° 58' 02".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. PROPORTION OF HEADWATER SPECIES	0	1
3. EVENNESS	0.184	1
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF OMNIVORE BIOMASS	88.3%	1
6. PROPORTION OF INSECTIVORE BIOMASS	11.7%	1
7. PROPORTION OF SIMPLE LITHOPHILS	5.9%	1
8. PROPORTION OF TOLERANT SPECIES	99.6%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	91.6%	1
11. NUMBER OF INDIVIDUALS/METER	18.9	5
12. PERCENT DELT	0	5
TOTAL IBI SCORE		24

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-104 Drainage Area: 116 mi^2 Date: 9-09-1994

Site: ND: Cass Co: Rush River, 5.3 mi W, 1.2 mi N of SH 18 at Amenia.
Long: 97° 19' 30" Lat: 47° 01' 21".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	6	3
2. PROPORTION OF HEADWATER SPECIES	2.3%	1
3. EVENNESS	0.232	1
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF OMNIVORE BIOMASS	90.1%	1
6. PROPORTION OF INSECTIVORE BIOMASS	9.9%	1
7. PROPORTION OF SIMPLE LITHOPHILS	5.8%	1
8. PROPORTION OF TOLERANT SPECIES	97.3	1
9. NUMBER OF SENSITIVE SPECIES	1	1
10. PROPORTION OF PIONEER SPECIES	91.5%	1
11. NUMBER OF INDIVIDUALS/METER	2.89	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		18

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-105 Drainage Area: 12 mi^2 Date: 9-09-1994

Site: ND: Cass Co: Tributary to Rush River, 2.5 mi S, .75 mi E Erie.
Long: 97° 22' 21" Lat: 47° 04' 44".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	4	5
2. PROPORTION OF HEADWATER SPECIES	45.3%	3
3. EVENNESS	0.637	3
4. NUMBER OF MINNOW SPECIES	2	5
5. PROPORTION OF OMNIVORE BIOMASS	72.7%	1
6. PROPORTION OF INSECTIVORE BIOMASS	27.3%	1
7. PROPORTION OF SIMPLE LITHOPHILS	39.4%	3
8. PROPORTION OF TOLERANT SPECIES	60.8%	3
9. NUMBER OF SENSITIVE SPECIES	1	5
10. PROPORTION OF PIONEER SPECIES	54.5%	3
11. NUMBER OF INDIVIDUALS/METER	8.22	5
12. PERCENT DELT	0	5
TOTAL IBI SCORE		42

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-106 Drainage Area: 58 mi^2 Date: 9-09-1994

Site: ND: Trail Co: Elm River, 2 mi E, .5 mi S Galesburg.
Long: 97° 21' 56" Lat: 47° 15' 39".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	2	1
2. PROPORTION OF HEADWATER SPECIES	8.4%	1
3. EVENNESS	0.416	1
4. NUMBER OF MINNOW SPECIES	1	1
5. PROPORTION OF OMNIVORE BIOMASS	94.5%	1
6. PROPORTION OF INSECTIVORE BIOMASS	5.5%	1
7. PROPORTION OF SIMPLE LITHOPHILS	0	1
8. PROPORTION OF TOLERANT SPECIES	1%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	91.6%	1
11. NUMBER OF INDIVIDUALS/METER	21 64	5
12. PERCENT DELT	0	5
TOTAL IBI SCORE		20

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-107 Drainage Area: 106 mi^2 Date: 9-09-1994

Site: ND: Trail Co: Elm River 2.5 mi S, 4 mi E, .2 mi S Blanchard.
Long: 97° 08' 01" Lat: 47° 18' 25".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	6	3
2. PROPORTION OF HEADWATER SPECIES	1.4%	1
3. EVENNESS	0.629	3
4. NUMBER OF MINNOW SPECIES	1	1
5. PROPORTION OF OMNIVORE BIOMASS	99.3%	1
6. PROPORTION OF INSECTIVORE BIOMASS	0.7%	1
7. PROPORTION OF SIMPLE LITHOPHILS	9.6%	1
8. PROPORTION OF TOLERANT SPECIES	97.3	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	42.5%	3
11. NUMBER OF INDIVIDUALS/METER	0.73	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		22

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-108 Drainage Area: 126 mi^2 Date: 9-09-1994

Site: ND: Trail Co: North Branch Elm River, 1 mi S, 2 mi E Kelso.
Long: 96° 59' 18" Lat: 47° 18' 40".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	2	1
2. PROPORTION OF HEADWATER SPECIES	78%	5
3. EVENNESS	0.76	3
4. NUMBER OF MINNOW SPECIES	1	1
5. PROPORTION OF OMNIVORE BIOMASS	48.4%	1
6. PROPORTION OF INSECTIVORE BIOMASS	51.6%	1
7. PROPORTION OF SIMPLE LITHOPHILS	0	1
8. PROPORTION OF TOLERANT SPECIES	1%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	22%	1
11. NUMBER OF INDIVIDUALS/METER	1.73	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		22*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-109 Drainage Area: 1203 mi^2 Date: 9-10-1994

Site: ND: Trail Co: Goose River, 4 mi E, 1.4 mi N Hillsboro.
Long: 96° 57' 49" Lat: 47° 25' 51".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	11	3
2. NUMBER OF BENTHIC INSECTIVORES	6	3
3. EVENNESS	0.813	5
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF PISCIVORE BIOMASS	22.9%	5
6. PROPORTION OF OMNIVORE BIOMASS	0.2%	5
7. PROPORTION OF INSECTIVORE BIOMASS	76.9%	5
8. PROPORTION OF SIMPLE LITHOPHILS	15%	1
9. PROPORTION OF TOLERANT SPECIES	47.5%	3
10. NUMBER OF SENSITIVE SPECIES	5	3
11. NUMBER OF INDIVIDUALS/METER	0.27	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		42

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-110 Drainage Area: 180 mi^2 Date: 9-10-1994

Site: ND: Trail Co: North Branch Goose River, 2 mi S, 5.5 mi E Mayville.
Long: 97° 12' 38" Lat: 47° 28' 09".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. PROPORTION OF HEADWATER SPECIES	4.1%	1
3. EVENNESS	0.43	1
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF OMNIVORE BIOMASS	25.3%	5
6. PROPORTION OF INSECTIVORE BIOMASS	74.7%	5
7. PROPORTION OF SIMPLE LITHOPHILS	2.5%	1
8. PROPORTION OF TOLERANT SPECIES	88.6%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	91.8%	1
11. NUMBER OF INDIVIDUALS/METER	6.32	3
12. PERCENT DELT	0	5
TOTAL IBI SCORE		28

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-111 Drainage Area: 478 mi^2 Date: 9-10-1994

Site: ND: Trail Co: Goose River, 6 mi S, .5 mi W Hatton.
Long: 97° 27' 33" Lat: 47° 32' 30".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	6	1
2. NUMBER OF BENTHIC INSECTIVORES	1	1
3. EVENNESS	0.868	5
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF PISCIVORE BIOMASS	49.2%	1
6. PROPORTION OF OMNIVORE BIOMASS	49.1%	1
7. PROPORTION OF INSECTIVORE BIOMASS	1.7%	1
8. PROPORTION OF SIMPLE LITHOPHILS	36.4%	1
9. PROPORTION OF TOLERANT SPECIES	63.6%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	0.22	1
12 PERCENT DELT	4.5	1
TOTAL IBI SCORE		16*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-112 Drainage Area: 180 mi^2 Date: 9-14-1994

Site: ND: Steele Co: Middle Branch Goose River, 8 mi W on Hwy 200, 1 mi S, 1 mi W Mayville.
Long: 97° 32' 16" Lat: 47° 30' 45".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. PROPORTION OF HEADWATER SPECIES	30%	3
3. EVENNESS	0.664	3
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF OMNIVORE BIOMASS	53.1%	3
6. PROPORTION OF INSECTIVORE BIOMASS	46.9%	3
7. PROPORTION OF SIMPLE LITHOPHILS	35.4%	3
8. PROPORTION OF TOLERANT SPECIES	47 3%	3
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	17.3%	5
11. NUMBER OF INDIVIDUALS/METER	1.73	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		36

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-113 Drainage Area: 160 mi^2 Date: 9-10-1994

Site: ND: Steele Co: Beaver Creek at USGS Gauge.
Long: 97° 42' 27" Lat: 47° 35' 37".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	4	1
2. PROPORTION OF HEADWATER SPECIES	2.7%	1
3. EVENNESS	0 705	3
4. NUMBER OF MINNOW SPECIES	2	1
5. PROPORTION OF OMNIVORE BIOMASS	62.8%	1
6. PROPORTION OF INSECTIVORE BIOMASS	37.2%	1
7. PROPORTION OF SIMPLE LITHOPHILS	17.5%	1
8. PROPORTION OF TOLERANT SPECIES	1%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	79.8%	1
11. NUMBER OF INDIVIDUALS/METER	7.42	5
12. PERCENT DELT	1.3%	3
TOTAL IBI SCORE		20*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-114 Drainage Area: 2200 mi^2 Date: 9-07-1994

Site: ND: Cass Co: Wild Rice River, 2.5 mi S, .3 mi W St. Benedict.
Long: 96° 50' 49" Lat: 46° 41' 17".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	8	1
2. PROPORTION OF LARGE RIVER SPECIES	5.5%	1
3. PROPORTION OF ROUND BODIED SUCKERS	1.8%	1
4. EVENNESS	0.807	5
5. PROPORTION OF PISCIVORE BIOMASS	5.2%	1
6. PROPORTION OF OMNIVORE BIOMASS	53.4%	1
7. PROPORTION OF INSECTIVORE BIOMASS	41.4%	1
8. PROPORTION OF SIMPLE LITHOPHILS	5.5%	1
9. PROPORTION OF TOLERANT SPECIES	63.6%	1
10. NUMBER OF SENSITIVE SPECIES	1	1
11. NUMBER OF INDIVIDUALS/METER	0.55	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		20*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-115 Drainage Area: 2000 mi^2 Date: 9-07-1994

Site: ND: Richland Co: Wild Rice River, 5.5 mi S, .4 mi W Abercrombie.
Long: 96° 44' 29" Lat: 46° 22' 11".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. PROPORTION OF LARGE RIVER SPECIES	0	1
3. PROPORTION OF ROUND BODIED SUCKERS	3.7%	1
4. EVENNESS	0.799	5
5. PROPORTION OF PISCIVORE BIOMASS	11.5%	3
6. PROPORTION OF OMNIVORE BIOMASS	53.9%	3
7. PROPORTION OF INSECTIVORE BIOMASS	34.6%	3
8. PROPORTION OF SIMPLE LITHOPHILS	14.8%	1
9. PROPORTION OF TOLERANT SPECIES	22.2%	5
10. NUMBER OF SENSITIVE SPECIES	1	1
11. NUMBER OF INDIVIDUALS/METER	0.27	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		32

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-116 Drainage Area: 1297 mi^2 Date: 9-07-1994

Site: Co: Richland Co: Wild Rice River, 3.5 mi N Hankinson.
Long: 96° 54' 24" Lat: 46° 07' 52".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE MOD.
1. TOTAL NUMBER OF SPECIES	6	1
2. NUMBER OF BENTHIC INSECTIVORES	1	1
3. EVENNESS	0.456	1
4. NUMBER OF MINNOW SPECIES	1	1
5. PROPORTION OF PISCIVORE BIOMASS	83.4%	1
6. PROPORTION OF OMNIVORE BIOMASS	15.2%	1
7. PROPORTION OF INSECTIVORE BIOMASS	1.4%	1
8. PROPORTION OF SIMPLE LITHOPHILS	4.3%	1
9. PROPORTION OF TOLERANT SPECIES	87.1%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	0.93	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		16*

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-117 Drainage Area: 215 mi^2 Date: 9-07-1994

Site: Co: Richland Co: Antelope Creek, 5.5 mi S, .8 mi W Abercrombie.
Long: 96° 45' 08" Lat: 46° 22' 11".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	6	3
2. NUMBER OF BENTHIC INSECTIVORES	2	1
3. EVENNESS	0.46	1
4. NUMBER OF MINNOW SPECIES	2	1
5. PROPORTION OF PISCIVORE BIOMASS	0	1
6. PROPORTION OF OMNIVORE BIOMASS	96.8%	1
7. PROPORTION OF INSECTIVORE BIOMASS	3.2%	1
8. PROPORTION OF SIMPLE LITHOPHILS	0.4%	1
9. PROPORTION OF TOLERANT SPECIES	98.3%	1
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	5.34	3
12. PERCENT DELT	0	5
TOTAL IBI SCORE		20

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-118 Drainage Area: 980 mi^2 Date: 9-07-1994

Site: Co: Richland Co: Bois de Sioux, 1.5 mi E Fairmount.
Long: 96° 33' 58" Lat: 46° 03' 03".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. NUMBER OF BENTHIC INSECTIVORES	3	1
3. EVENNESS	0.654	3
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF PISCIVORE BIOMASS	29.4%	5
6. PROPORTION OF OMNIVORE BIOMASS	3.1%	5
7. PROPORTION OF INSECTIVORE BIOMASS	64.2%	5
8. PROPORTION OF SIMPLE LITHOPHILS	1.1%	1
9. PROPORTION OF TOLERANT SPECIES	51.1%	3
10. NUMBER OF SENSITIVE SPECIES	1	1
11. NUMBER OF INDIVIDUALS/METER	0.61	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		34

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-119 Drainage Area: 4200 mi^2 Date: 9-07-1994

Site: Co: Richland Co: Red River at Brushvale.
Long: 96° 39' 24" Lat: 46° 22' 11".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	15	3
2. PROPORTION OF LARGE RIVER SPECIES	29.9%	3
3. PROPORTION OF ROUND BODIED SUCKERS	2.5%	1
4. EVENNESS	0.474	1
5. PROPORTION OF PISCIVORE BIOMASS	31.4%	3
6. PROPORTION OF OMNIVORE BIOMASS	21.9%	5
7. PROPORTION OF INSECTIVORE BIOMASS	46.6%	3
8. PROPORTION OF SIMPLE LITHOPHILS	5.1%	1
9. PROPORTION OF TOLERANT SPECIES	3.2%	5
10. NUMBER OF SENSITIVE SPECIES	6	3
11. NUMBER OF INDIVIDUALS/METER	1.05	1
12. PERCENT DELT	1.9	3
TOTAL IBI SCORE		32

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-120 Drainage Area: 51 mi^2 Date: 9-08-1994

Site: ND: Cass Co: Swan Creek, 2 mi N, 4 mi W, .5 mi N Casselton.
Long: 97° 18' 09" Lat: 46° 56' 17".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. PROPORTION OF HEADWATER SPECIES	10.2%	1
3. EVENNESS	0.506	1
4. NUMBER OF MINNOW SPECIES	5	5
5. PROPORTION OF OMNIVORE BIOMASS	51.3%	3
6. PROPORTION OF INSECTIVORE BIOMASS	48.5%	3
7. PROPORTION OF SIMPLE LITHOPHILS	3.7%	1
8. PROPORTION OF TOLERANT SPECIES	91.4%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	75.9%	1
11. NUMBER OF INDIVIDUALS/METER	3.74	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		26

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-121 Drainage Area: 1275 mi^2 Date: 9-08-1994

Site: ND: Cass Co: Maple River, 1 mi S, 3 mi W Mapleton.
Long: 97° 06' 59" Lat: 46° 51' 41".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	8	3
2. NUMBER OF BENTHIC INSECTIVORES	2	1
3. EVENNESS	0.393	1
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF PISCIVORE BIOMASS	33.2%	3
6. PROPORTION OF OMNIVORE BIOMASS	28.6%	5
7. PROPORTION OF INSECTIVORE BIOMASS	38.2%	3
8. PROPORTION OF SIMPLE LITHOPHILS	1.5%	1
9. PROPORTION OF TOLERANT SPECIES	26.1%	5
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	1.33	1
12. PERCENT DELT	0	5
	TOTAL IBI SCORE	30

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-122 Drainage Area: 1022 mi^2 Date: 9-08-1994

Site: ND: Cass Co: Maple River, .5 mi W, 3 mi S, .5 mi W, 1.5 mi S Chaffee.
Long: 97° 22' 45" Lat: 46° 42' 39".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	10	3
2. NUMBER OF BENTHIC INSECTIVORES	4	3
3. EVENNESS	0.835	5
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF PISCIVORE BIOMASS	37%	3
6. PROPORTION OF OMNIVORE BIOMASS	30%	5
7. PROPORTION OF INSECTIVORE BIOMASS	33%	3
8. PROPORTION OF SIMPLE LITHOPHILS	31.1%	3
9. PROPORTION OF TOLERANT SPECIES	56.3%	3
10. NUMBER OF SENSITIVE SPECIES	1	1
11. NUMBER OF INDIVIDUALS/METER	1.03	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		38

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-123 Drainage Area: 594 mi^2 Date: 9-08-1994

Site: ND: Cass Co: Maple River, 1 mi N, 2.6 mi W Alice.
Long: 97° 36' 40" Lat: 46° 46' 29".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. NUMBER OF BENTHIC INSECTIVORES	4	3
3. EVENNESS	0.849	5
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF PISCIVORE BIOMASS	25.8%	5
6. PROPORTION OF OMNIVORE BIOMASS	51.3%	3
7. PROPORTION OF INSECTIVORE BIOMASS	22.9%	1
8. PROPORTION OF SIMPLE LITHOPHILS	23.5%	1
9. PROPORTION OF TOLERANT SPECIES	41.7%	3
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	2.3	1
12. PERCENT DELT	0.4	5
	TOTAL IBI SCORE	32

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-124 Drainage Area: 69 mi^2 Date: 9-08-1994

Site: ND: Steele Co: Maple River, 3.5 mi W, .5 mi N Colgate.
Long: 97° 43' 38" Lat: 47° 14' 47".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	7	3
2. PROPORTION OF HEADWATER SPECIES	10.7%	1
3. EVENNESS	0.375	1
4. NUMBER OF MINNOW SPECIES	2	1
5. PROPORTION OF OMNIVORE BIOMASS	28.6%	5
6. PROPORTION OF INSECTIVORE BIOMASS	4.3%	1
7. PROPORTION OF SIMPLE LITHOPHILS	0.5%	1
8. PROPORTION OF TOLERANT SPECIES	96.9%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	80.4%	1
11. NUMBER OF INDIVIDUALS/METER	11.76	5
12. PERCENT DELT	0	5
TOTAL IBI SCORE		26

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-125 Drainage Area: 148 mi^2 Date: 7-27-1994

Site: ND: Grand Forks Co: North Branch Turtle River, SH 18 bridge, 3 mi N of Hwy 2 Junct.
Long: 97° 37' 25" Lat: 47° 59' 31".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	10	5
2. PROPORTION OF HEADWATER SPECIES	44.6%	3
3. EVENNESS	0.54	1
4. NUMBER OF MINNOW SPECIES	6	3
5. PROPORTION OF OMNIVORE BIOMASS	24.6%	5
6. PROPORTION OF INSECTIVORE BIOMASS	75.4%	5
7. PROPORTION OF SIMPLE LITHOPHILS	48.6%	3
8. PROPORTION OF TOLERANT SPECIES	55.2%	3
9. NUMBER OF SENSITIVE SPECIES	1	1
10. PROPORTION OF PIONEER SPECIES	10.8%	5
11. NUMBER OF INDIVIDUALS/METER	10.84	5
12. PERCENT DELT	0.1	5
TOTAL IBI SCORE		44

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-126 Drainage Area: 148 mi^2 Date: 7-28-1994

Site: ND: Grand Forks Co: North Branch Turtle River, SH 18 bridge, 3 mi N of Hwy 2 Junct.
Long: 97° 37' 25" Lat: 47° 59' 31".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. PROPORTION OF HEADWATER SPECIES	48.4%	3
3. EVENNESS	0.604	3
4. NUMBER OF MINNOW SPECIES	5	3
5. PROPORTION OF OMNIVORE BIOMASS	21.6%	5
6. PROPORTION OF INSECTIVORE BIOMASS	78%	5
7. PROPORTION OF SIMPLE LITHOPHILS	50.9%	3
8. PROPORTION OF TOLERANT SPECIES	62.1%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	16.2%	5
11. NUMBER OF INDIVIDUALS/METER	7	3
12. PERCENT DELT	0.4	5
TOTAL IBI SCORE		40

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-127 Drainage Area: 295 mi^2 Date: 7-25-1994

Site: ND: Pembina Co: Tongue River, SH 18, 3.25 mi SW Bathgate.
Long: 97° 33' 22" Lat: 48° 51' 06".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	7	3
2. NUMBER OF BENTHIC INSECTIVORES	2	1
3. EVENNESS	0.851	5
4. NUMBER OF MINNOW SPECIES	3	1
5. PROPORTION OF PISCIVORE BIOMASS	0	1
6. PROPORTION OF OMNIVORE BIOMASS	34.9%	3
7. PROPORTION OF INSECTIVORE BIOMASS	65.1%	5
8. PROPORTION OF SIMPLE LITHOPHILS	46%	3
9. PROPORTION OF TOLERANT SPECIES	51.8%	3
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	1.39	1
12. PERCENT DELT	13.7%	1
TOTAL IBI SCORE		28

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-128 Drainage Area: 3200 mi^2 Date: 7-25-1994

Site: ND: Pembina Co: Pembina River, SH 32 bridge, 0.75 mi S Walhalla.
Long: 97° 55' 01" Lat: 48° 54' 49".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	14	3
2. PROPORTION OF LARGE RIVER SPECIES	0	1
3. PROPORTION OF ROUND BODIED SUCKERS	0	1
4. EVENNESS	0.712	3
5. PROPORTION OF PISCIVORE BIOMASS	12.8%	3
6. PROPORTION OF OMNIVORE BIOMASS	12.4%	5
7. PROPORTION OF INSECTIVORE BIOMASS	70.6%	5
8. PROPORTION OF SIMPLE LITHOPHILS	19.4%	1
9. PROPORTION OF TOLERANT SPECIES	34.8%	3
10. NUMBER OF SENSITIVE SPECIES	5	3
11. NUMBER OF INDIVIDUALS/METER	1.4	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		34

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-129 Drainage Area: 66 mi^2 Date: 7-26-1994

Site: ND: Pembina Co: North Branch Park River, 6 mi N Edinburg.
Long: 97° 51' 42" Lat: 48° 35' 26".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	5	3
2. PROPORTION OF HEADWATER SPECIES	23.5%	1
3. EVENNESS	0.756	3
4. NUMBER OF MINNOW SPECIES	3	3
5. PROPORTION OF OMNIVORE BIOMASS	10.6%	5
6. PROPORTION OF INSECTIVORE BIOMASS	32.3%	3
7. PROPORTION OF SIMPLE LITHOPHILS	20.8%	1
8. PROPORTION OF TOLERANT SPECIES	98.6%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	75.2%	1
11. NUMBER OF INDIVIDUALS/METER	6.33	3
12. PERCENT DELT	0.5%	5
TOTAL IBI SCORE		30

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-130 Drainage Area: 416 mi^2 Date: 7-27-1994

Site: ND: Grand Forks Co: Forest River, 2 mi N Inkster.
Long: 97° 38' 37" Lat: 48° 10' 46".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	13	3
2. NUMBER OF BENTHIC INSECTIVORES	6	3
3. EVENNESS	0.706	3
4. NUMBER OF MINNOW SPECIES	8	5
5. PROPORTION OF PISCIVORE BIOMASS	8.5%	1
6. PROPORTION OF OMNIVORE BIOMASS	6.5%	5
7. PROPORTION OF INSECTIVORE BIOMASS	77.6%	5
8. PROPORTION OF SIMPLE LITHOPHILS	37.7%	3
9. PROPORTION OF TOLERANT SPECIES	43.8%	3
10. NUMBER OF SENSITIVE SPECIES	3	3
11. NUMBER OF INDIVIDUALS/METER	9.02	5
12. PERCENT DELT	0.1%	5
TOTAL IBI SCORE		44

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-131 Drainage Area: 180 mi^2 Date: 9-14-1994

Site: ND: Trail Co: North Branch Goose River, 2 mi S, 5.5 mi E Mayville.
Long: 97° 12' 38" Lat: 47° 28' 09".

METRIC (for headwater streams <200 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	9	3
2. PROPORTION OF HEADWATER SPECIES	6.5%	1
3. EVENNESS	0.46	1
4. NUMBER OF MINNOW SPECIES	4	3
5. PROPORTION OF OMNIVORE BIOMASS	34.3%	3
6. PROPORTION OF INSECTIVORE BIOMASS	65.7%	5
7. PROPORTION OF SIMPLE LITHOPHILS	0.8%	1
8. PROPORTION OF TOLERANT SPECIES	80%	1
9. NUMBER OF SENSITIVE SPECIES	0	1
10. PROPORTION OF PIONEER SPECIES	85.8%	1
11. NUMBER OF INDIVIDUALS/METER	5.2	3
12. PERCENT DELT	0	5
	TOTAL IBI SCORE	28

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-502 Drainage Area: 254 mi^2 Date: 8-09-1994

Site: ND: Grand Forks Co: Turtle River at State Park, reach # 2.
Long: 97° 30' 00" Lat: 47° 56' 18".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	12	5
2. NUMBER OF BENTHIC INSECTIVORES	7	5
3. EVENNESS	0.731	3
4. NUMBER OF MINNOW SPECIES	7	5
5. PROPORTION OF PISCIVORE BIOMASS	0	1
6. PROPORTION OF OMNIVORE BIOMASS	17.9%	5
7. PROPORTION OF INSECTIVORE BIOMASS	82.1%	5
8. PROPORTION OF SIMPLE LITHOPHILS	18.2%	1
9. PROPORTION OF TOLERANT SPECIES	53.5%	3
10. NUMBER OF SENSITIVE SPECIES	2	3
11. NUMBER OF INDIVIDUALS/METER	5.46	3
12. PERCENT DELT	3.8%	3
TOTAL IBI SCORE		42

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-503 Drainage Area: 405 mi^2 Date: 8-18-1994

Site: ND: Grand Forks Co: Forest River near Fordville.
Long: 97° 43' 49" Lat: 48° 11' 50".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	16	5
2. NUMBER OF BENTHIC INSECTIVORES	6	3
3. EVENNESS	0.687	3
4. NUMBER OF MINNOW SPECIES	9	5
5. PROPORTION OF PISCIVORE BIOMASS	12.9%	3
6. PROPORTION OF OMNIVORE BIOMASS	32.6%	3
7. PROPORTION OF INSECTIVORE BIOMASS	54.2%	3
8. PROPORTION OF SIMPLE LITHOPHILS	14.4%	1
9. PROPORTION OF TOLERANT SPECIES	40.7%	3
10. NUMBER OF SENSITIVE SPECIES	3	3
11. NUMBER OF INDIVIDUALS/METER	20.73	5
12. PERCENT DELT	0.7%	5
TOTAL IBI SCORE		42

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-504 Drainage Area: 1240 mi^2 Date: 8-30-1994

Site: ND: Trail Co: Goose River at Hillsboro.
Long: 97° 03' 39" Lat: 47° 24' 34".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	20	5
2. NUMBER OF BENTHIC INSECTIVORES	5	3
3. EVENNESS	0.645	3
4. NUMBER OF MINNOW SPECIES	7	5
5. PROPORTION OF PISCIVORE BIOMASS	37.8%	3
6. PROPORTION OF OMNIVORE BIOMASS	31.6%	5
7. PROPORTION OF INSECTIVORE BIOMASS	30.6%	3
8. PROPORTION OF SIMPLE LITHOPHILS	28.3%	1
9. PROPORTION OF TOLERANT SPECIES	29%	5
10. NUMBER OF SENSITIVE SPECIES	3	3
11. NUMBER OF INDIVIDUALS/METER	0.97	1
12. PERCENT DELT	0	5
TOTAL IBI SCORE		42

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-505 Drainage Area: 3202 mi^2 Date: 8-17-1994

Site: ND: Pembina Co: Pembina River at Walhalla.
Long: 97° 55' 00" Lat: 48° 54' 50".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	19	5
2. PROPORTION OF LARGE RIVER SPECIES	0	1
3. PROPORTION OF ROUND BODIED SUCKERS	0.3%	1
4. EVENNESS	0.631	3
5. PROPORTION OF PISCIVORE BIOMASS	31%	3
6. PROPORTION OF OMNIVORE BIOMASS	2.3%	5
7. PROPORTION OF INSECTIVORE BIOMASS	64.2%	5
8. PROPORTION OF SIMPLE LITHOPHILS	68.1%	1
9. PROPORTION OF TOLERANT SPECIES	36.6%	3
10. NUMBER OF SENSITIVE SPECIES	6	3
11. NUMBER OF INDIVIDUALS/METER	6.06	5
12. PERCENT DELT	0.4%	5
TOTAL IBI SCORE		40

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-523 Drainage Area: 254 mi^2 Date: 8-09-1994

Site: ND: Grand Forks Co: Turtle River at State Park, reach # 1.
Long: 97° 30' 00" Lat: 47° 56' 18".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	16	5
2. NUMBER OF BENTHIC INSECTIVORES	7	5
3. EVENNESS	0.75	3
4. NUMBER OF MINNOW SPECIES	7	5
5. PROPORTION OF PISCIVORE BIOMASS	6.4%	1
6. PROPORTION OF OMNIVORE BIOMASS	22.7%	5
7. PROPORTION OF INSECTIVORE BIOMASS	62.8%	5
8. PROPORTION OF SIMPLE LITHOPHILS	19.6%	1
9. PROPORTION OF TOLERANT SPECIES	57.8%	3
10. NUMBER OF SENSITIVE SPECIES	3	3
11. NUMBER OF INDIVIDUALS/METER	3.02	1
12. PERCENT DELT	2%	3
TOTAL IBI SCORE		40

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-524 Drainage Area: 254 mi^2 Date: 8-10-1994

Site: ND: Grand Forks Co: Turtle River at State Park, reach # 3.
Long: 97° 30' 00" Lat: 47° 56' 18".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	12	5
2. NUMBER OF BENTHIC INSECTIVORES	7	5
3. EVENNESS	0.805	5
4. NUMBER OF MINNOW SPECIES	7	5
5. PROPORTION OF PISCIVORE BIOMASS	0	1
6. PROPORTION OF OMNIVORE BIOMASS	12.3%	5
7. PROPORTION OF INSECTIVORE BIOMASS	81.3%	5
8. PROPORTION OF SIMPLE LITHOPHILS	30.7%	3
9. PROPORTION OF TOLERANT SPECIES	57.8%	3
10. NUMBER OF SENSITIVE SPECIES	3	3
11. NUMBER OF INDIVIDUALS/METER	3.02	1
12. PERCENT DELT	2%	3
TOTAL IBI SCORE		44

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-525 Drainage Area: 4490 mi^2 Date: 8-25-1994

Site: ND: Ransom Co: Sheyenne River at Lisbon, reach # 2.
Long: 97° 40' 44" Lat: 46° 26' 49".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	23	5
2. PROPORTION OF LARGE RIVER SPECIES	1.8%	1
3. PROPORTION OF ROUND BODIED SUCKERS	13.1%	1
4. EVENNESS	0.714	3
5. PROPORTION OF PISCIVORE BIOMASS	13.4%	3
6. PROPORTION OF OMNIVORE BIOMASS	45.5%	3
7. PROPORTION OF INSECTIVORE BIOMASS	41.2%	3
8. PROPORTION OF SIMPLE LITHOPHILS	22.9%	1
9. PROPORTION OF TOLERANT SPECIES	21.8%	5
10. NUMBER OF SENSITIVE SPECIES	6	3
11. NUMBER OF INDIVIDUALS/METER	1.83	3
12. PERCENT DELT	3.6%	3
TOTAL IBI SCORE		34

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-526 Drainage Area: 4490 mi^2 Date: 8-25-1994

Site: ND: Ransom Co: Sheyenne River at Lisbon, reach # 1.
Long: 97° 40' 44" Lat: 46° 26' 49".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	22	5
2. PROPORTION OF LARGE RIVER SPECIES	2.2%	1
3. PROPORTION OF ROUND BODIED SUCKERS	11.2	1
4. EVENNESS	0.691	3
5. PROPORTION OF PISCIVORE BIOMASS	24.8%	5
6. PROPORTION OF OMNIVORE BIOMASS	13.1%	5
7. PROPORTION OF INSECTIVORE BIOMASS	62.1%	5
8. PROPORTION OF SIMPLE LITHOPHILS	19.1%	1
9. PROPORTION OF TOLERANT SPECIES	19.7%	5
10. NUMBER OF SENSITIVE SPECIES	9	5
11. NUMBER OF INDIVIDUALS/METER	1.19	1
12. PERCENT DELT	2.8%	3
TOTAL IBI SCORE		40

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-527 Drainage Area: 1877 mi^2 Date: 8-17-1994

Site: ND: Eddy Co: Sheyenne River S of Warwick.
Long: 98° 42' 57" Lat: 47° 48' 20".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	17	5
2. PROPORTION OF LARGE RIVER SPECIES	0.9%	1
3. PROPORTION OF ROUND BODIED SUCKERS	0	1
4. EVENNESS	0.785	5
5. PROPORTION OF PISCIVORE BIOMASS	9.4%	1
6. PROPORTION OF OMNIVORE BIOMASS	49.3%	3
7. PROPORTION OF INSECTIVORE BIOMASS	41.3%	3
8. PROPORTION OF SIMPLE LITHOPHILS	26.5%	1
9. PROPORTION OF TOLERANT SPECIES	41.4%	3
10. NUMBER OF SENSITIVE SPECIES	3	1
11. NUMBER OF INDIVIDUALS/METER	12.74	5
12. PERCENT DELT	1.2%	3
TOTAL IBI SCORE		32

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-528 Drainage Area: 31680 mi^2 Date: 9-02-1994

Site: ND: Pembina Co: Red River E of Joliette, reach # 2.
Long: 97° 10' 43" Lat: 48° 48' 51".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	18	5
2. PROPORTION OF LARGE RIVER SPECIES	58.5%	5
3. PROPORTION OF ROUND BODIED SUCKERS	0	1
4. EVENNESS	0.787	5
5. PROPORTION OF PISCIVORE BIOMASS	36.4%	3
6. PROPORTION OF OMNIVORE BIOMASS	19.9%	5
7. PROPORTION OF INSECTIVORE BIOMASS	43.6%	3
8. PROPORTION OF SIMPLE LITHOPHILS	17.1%	1
9. PROPORTION OF TOLERANT SPECIES	20.3%	5
10. NUMBER OF SENSITIVE SPECIES	5	3
11. NUMBER OF INDIVIDUALS/METER	0.26	5
12. PERCENT DELT	0	5
TOTAL IBI SCORE		46

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-529 Drainage Area: 31680 mi^2 Date: 9-02-1994

Site: ND: Pembina Co: Red River E of Joliette, reach # 3.
Long: 97° 10' 43" Lat: 48° 48' 51".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	16	3
2. PROPORTION OF LARGE RIVER SPECIES	64.9%	5
3. PROPORTION OF ROUND BODIED SUCKERS	3.1%	1
4. EVENNESS	0.907	5
5. PROPORTION OF PISCIVORE BIOMASS	21%	3
6. PROPORTION OF OMNIVORE BIOMASS	3.1%	5
7. PROPORTION OF INSECTIVORE BIOMASS	75.8%	5
8. PROPORTION OF SIMPLE LITHOPHILS	37.1%	3
9. PROPORTION OF TOLERANT SPECIES	17.5%	5
10. NUMBER OF SENSITIVE SPECIES	5	3
11. NUMBER OF INDIVIDUALS/METER	0.19	5
12. PERCENT DELT	0	5
TOTAL IBI SCORE		48

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-530 Drainage Area: 31680 mi^2 Date: 9-02-1994

Site: ND: Pembina Co: Red River E of Joliette, reach # 1.
Long: 97° 10' 43" Lat: 48° 48' 51".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	18	5
2. PROPORTION OF LARGE RIVER SPECIES	46%	3
3. PROPORTION OF ROUND BODIED SUCKERS	1.4%	1
4. EVENNESS	0.872	5
5. PROPORTION OF PISCIVORE BIOMASS	39.8%	3
6. PROPORTION OF OMNIVORE BIOMASS	9.2%	5
7. PROPORTION OF INSECTIVORE BIOMASS	50.8%	3
8. PROPORTION OF SIMPLE LITHOPHILS	22.3%	1
9. PROPORTION OF TOLERANT SPECIES	13.7%	5
10. NUMBER OF SENSITIVE SPECIES	6	3
11. NUMBER OF INDIVIDUALS/METER	0.28	5
12. PERCENT DELT	0	5
TOTAL IBI SCORE		44

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-531 Drainage Area: 6690 mi^2 Date: 8-11-1994

Site: ND: Cass Co: Red River at Fargo.
Long: 97° 47' 00" Lat: 46° 51' 40".

METRIC (for large streams >1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	16	3
2. PROPORTION OF LARGE RIVER SPECIES	53.4%	5
3. PROPORTION OF ROUND BODIED SUCKERS	0.2%	1
4. EVENNESS	0.355	1
5. PROPORTION OF PISCIVORE BIOMASS	9%	1
6. PROPORTION OF OMNIVORE BIOMASS	66.5%	1
7. PROPORTION OF INSECTIVORE BIOMASS	24.5%	1
8. PROPORTION OF SIMPLE LITHOPHILS	0.5%	1
9. PROPORTION OF TOLERANT SPECIES	2.3%	5
10. NUMBER OF SENSITIVE SPECIES	6	3
11. NUMBER OF INDIVIDUALS/METER	6.61	5
12. PERCENT DELT	0	5
TOTAL IBI SCORE		32

LAKE AGASSIZ PLAIN BIOCRITERIA STUDY

Station Number: 94-533 Drainage Area: 828 mi^2 Date: 8-11-1994

Site: ND: Ransom Co: Maple River at Enderlin.
Long: 97° 34' 25" Lat: 46° 37' 18".

METRIC (for moderate size streams 200-1500 mi^2)	ACTUAL OBSERVATION	IBI SCORE
1. TOTAL NUMBER OF SPECIES	12	3
2. NUMBER OF BENTHIC INSECTIVORES	5	3
3. EVENNESS	0.538	1
4. NUMBER OF MINNOW SPECIES	6	3
5. PROPORTION OF PISCIVORE BIOMASS	7.9%	1
6. PROPORTION OF OMNIVORE BIOMASS	10.6%	5
7. PROPORTION OF INSECTIVORE BIOMASS	81.4%	5
8. PROPORTION OF SIMPLE LITHOPHILS	16.5%	1
9. PROPORTION OF TOLERANT SPECIES	29.4%	5
10. NUMBER OF SENSITIVE SPECIES	0	1
11. NUMBER OF INDIVIDUALS/METER	7.98	5
12. PERCENT DELT	0.4%	5
TOTAL IBI SCORE		38

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 1998	FINAL

4. TITLE AND SUBTITLE
Development of Index of Biotic Integrity Expectations for the Lake Agassiz Plain Ecoregion.

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Environmental Protection Agency
Watershed and Non-Point Source Branch
77 West Jackson Blvd., WW-16J
Chicago, Illinois 60604

8. PERFORMING ORGANIZATION REPORT NUMBER
EPA 905/R-96-005

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Minnesota Pollution Control Agency
North Dakota Department of Health
U.S. Geological Survey

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
UNLIMITED

12b. DISTRIBUTION CODE
UNLIMITED

13. ABSTRACT *(Maximum 200 words)*

The index of biotic integrity (IBI) has been used to evaluate biological quality of rivers and streams in diverse areas of the United States. The IBI compares characteristics of lotic systems, termed "metrics", that represents the structural and functional attributes of the fish community in three categories: 1) species richness and composition, 2) trophic structure, and 3) fish abundance and health. Comparisons are made with lotic systems possessing unaffected or minimally affected communities from ecologically similar areas. Modifications of the metrics have been made to account for regional or local characteristics of fish communities. A combined project between the USGS; USEPA, Region V and VIII; Minnesota Pollution Control Agency, Minnesota DNR; and the North Dakota Department of Health, Division of Water Quality targeted the multi-state Lake Agassiz Plain (formerly the Red River Valley) ecoregion for IBI development and assessment. All of the metrics have been modified for application to this biologically young (since glaciation) system. Several new metrics are proposed for various stream sizes in the Lake Agassiz Plain ecoregion. New metrics include the evenness component of diversity, trophic composition metrics based on biomass, a new omnivore definition, and as an alternative metric, the number of subterminal mouth cyprinids.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Biological integrity, Biological assessment, ecoregions, IBI	60 + appendicies
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19 SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR